MUDDY CREEK FOLLOWUP PROJECT - 2005
Final Report

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Overview/Preface

Muddy Creek, located in North Central Montana near Great Falls, is a tributary of the Sun River. Muddy Creek is 42 miles long and accumulates flow from a 314 square mile drainage area. The Greenfield's Irrigation District (GID) irrigates approximately 50,000 acres that fall within the Muddy Creek drainage. Reportedly, the implementation of irrigation projects in the 1920's significantly increased flows in Muddy Creek, and it appears that these increased flows have resulted in erosion of stream banks and increased sediment loads delivered to the Sun River.

Substantial improvements have been made in decreasing sediment loads and stream bank erosion in Muddy Creek. Yet, Muddy Creek and the Sun River below Muddy Creek are still considered impaired by the Montana Department of Environmental Quality and are listed on the Montana 303(d) list. Muddy Creek and the Sun River below Muddy Creek are both unable to meet their designated uses, mostly due to excessive sediment loads, fluctuating flows, and fisheries habitat modification.

In 2002 and 2003, Montana State University-Bozeman was contracted to complete a study on the sources and amounts of flow and sediment within Muddy Creek and to determine relationships between Muddy Creek and tributary discharges and sediment. Sediment and flow were monitored at 13 locations along the Muddy Creek channel, at confluences of tributaries to Muddy Creek, and up gradient from tributary confluences with Muddy Creek. The study revealed that flow within Muddy Creek at Vaughn was influenced the greatest by inflows of water originating from tributaries within the GID boundary. During this same time period, the majority of sediment measured at Vaughn originated in the reach of Muddy Creek between Muddy Creek tributary #1 and Vaughn. This study helped to pinpoint areas where follow-up is needed to completely understand the sediment and flow patterns in Muddy Creek and the tributaries. Those areas are as follows:

- Additional data is needed to understand flows in Muddy Creek above Power. In the 2002/2003 study, data gathered at the Power monitoring station indicated that there was a significant increase in flow in Muddy Creek at Power coincident with the initiation of GID irrigation deliveries. Correspondingly, flows at Power reflect a significant decrease when GID discontinued irrigation deliveries. It appears that either operational spills, canal over runs, or farm field irrigation return flow contribute significantly to flows in Muddy Creek at some location upstream from the Power monitoring station.

- A detailed assessment is needed of MC#1 and Tank Coulee, both tributaries of Muddy Creek. In the previous study, data gathered showed very significant increases in both flow and sediment from the upper to lower portions of the drainages of these two tributaries. During the 2003 irrigation season, flow volume in Tank Coulee increased 2,771 acre-feet and sediment load increased by 481 tons between the upper and middle portions of Tank Coulee. Correspondingly, flow increased 3,850 acre-feet between the middle and lower portions of Tank Coulee and sediment increased by 1,322 tons during the same time period. Flow within MC#1 increased 1,851 acre-feet and sediment increased by 776 tons between the upper and lower portions of this drainage. The factors contributing to increases in both flow and sediment in these tributaries are not understood.

In an effort to address these issues, the Sun River Watershed Group contracted with Montana State University Extension Water Quality to define and quantify surface (and where possible groundwater) sources contributing flows and sediment to Muddy Creek tributary #1, Tank Coulee, and Muddy Creek above Power.

Approach

With the guidance of GID staff and the Sun River watershed coordinator, sixteen sites were selected for monitoring (Figure 1). At each of these sites an aquarod or tru-track was installed in a stilling well. Aquarods and tru-tracks log water level and water temperature on a continuous basis. Aquarods and tru-tracks used in this project were set to record stream height every 30 minutes. Additionally, staff gauges were installed at many of these sampling sites.

After initial installation of equipment, each sampling site was visited once before the onset of irrigation season, twice a month during the irrigation season, and once following the irrigation season. Flow was measured during these visits using a Marsh-McBirney Model 2000 Flo-Mate portable flowmeter. Flow measurements made with the flow meter were correlated with aquarod and tru-track stage height measurements to develop rating curves for the water level measurements logged by the aquarods and tru-tracks at each gauging station. In addition, sediment samples were collected at all of the sites bimonthly. Sediment samples were then transported back to Montana State University for analysis. Flow and sediment data were organized for each gauging station and subsequently used to determine instantaneous flow, time-dependent flow, and average daily flow and daily sediment in tons for each monitoring site for the 2005 irrigation season. Efforts were undertaken to define relationships between flow rate (cfs) and sediment concentration (mg/L) at each gauging station. Data collected prior to and after the specific period when water was reportedly being diverted for irrigation purposes (the irrigation season) was used solely for calibration purposes and was not included in the calculations of irrigation-season-related flow or sediment. Where appropriate, these data were reported and identified accordingly.

This project can be divided into three portions: 1. Muddy Creek tributary #1 (MC#1), 2. Tank Coulee, and 3. above Power. On August 4, 2004, the Sun River Watershed coordinator and an MSU water quality associate walked the entire stretch of MC#1. All identifiable sources of water (seeps, tributaries, overland flows, etc.) were noted and located with a handheld GPS unit. This information helped with the location of monitoring sites on MC#1. Three monitoring sites were located on MC#1, two on MC#1 proper (Lower MC trib #1 and Upper MC trib #1) and one on a trib to MC#1 (MC trib at Sands). Notes from this scoping trip are included in the appendix.

Five sites were located within the Tank Coulee watershed. Three monitoring sites were located on Tank Coulee (Upper, Middle, and Lower Tank Coulee). The additional sites were located on tributaries to Tank Coulee (Creek below GS 51 EXT, Towers).

With additional guidance from Montana Fish, Wildlife, and Parks, eight monitoring sites were installed to understand flow and sediment above Power.

GID turned water out into canals on May 14, 2005 and discontinued diversions August 20, 2005. The 2005 irrigation season was thus determined to run from May 14th – August 20th and all flow and sediment calculations were made for this period of time. Note: unless otherwise stated, all flow and sediment load values reported in figures and tables included in this report apply to the period of May 14 through August 20, 2005. Data collected and presented for periods outside of these dates was used solely for calibration, determination of baseline conditions, or for illustration purposes. Data collected prior to or after the defined irrigation season (which is defined as the period of diversion or shortly after diversion was discontinued) is identified as such in the accompanying figures and tables.

Observations and Measurements

Calculations made were total flow (acre ft), total sediment (tons), sediment concentration (tons/acre ft), and average flow rate (cfs) for the irrigation season, that being the period from May 14 through August 20, 2005 (Table 1). Rating curves, flow x sediment concentration curves, and regressions for each gauging and monitoring station are included within the Appendix. Figure 2 presents a composite flow diagram of all flow and sediment determinations made along with GID reported spills and gains and losses in flow and sediment calculated between reaches within the study area.

Table 1. Total Flow and Total Sediment for Big Coulee and Duck Creek for 2005 – Irrigation Season (May 14 – August 20)

Station	Source	Total Flow (acre feet)	Total Sediment (tons)	Sediment (tons/acre ft)	Average Flow Rate (cfs)
Muddy Creek Tributary #1					
LMC#1	Aquarod	2,817	1,142	0.41	14
UMC#1	GID	1,059	17	0.02	4
MC @ Sands	Tru-track	501	14	0.03	3

Tank Coulee					
LTC	Aquarod	9,911	1,253	0.13	51
MTC	Aquarod	5,231	177	0.04	27
UTC	Aquarod	3,181	69	0.02	16
Creek below GS 51 EXT	Tru-track	2,315	63	0.03	12
Towers	Tru-track	545	0	0	3
Above Power					
Power	Estimate	6,212	637	0.10	32
Cordova	Aquarod	3,761	625	0.17	19
Cordova at Side Coulee	Estimate	3,169	419	0.13	16
McAlpine	Aquarod	2,485	10	0.00	12
Cliev*	Tru-Track	1,910	83	0.04	10
Upper Kloppel Coulee	Tru-Track	1,232	12	0.01	6
Lower Kloppel Coulee	Tru-Track **	695	7	0.01	4
Freezout	Tru-Track ***	1,247	66	0.05	4

*Cliev – Due to equipment failure, flows are estimated from 8/8 – 8/20.
**Lower Kloppel Coulee – Due to equipment failure, flows are estimated from 5/14-6/2.
***Freezout – Due to equipment failure, flows were estimated from 7/27–8/8.

Flow Patterns

Figure 3 depicts average daily flows measured at the three stations located in the MC#1 drainage. Flow at Upper MC#1 (blue line) is directly in response to GID releases down MC#1. Water only flows past this station during the irrigation season. Flow at the Lower MC#1 (pink line) station tracks the flow in Upper MC#1, but with a definite increase. Some of this increase in flow between these two stations is attributable to the tributary to MC#1, identified as MC trib at Sands (green line). Additionally, figure 2 shows that there are several GID spills that contribute to flows measured at MC#1. The remaining balance of flow measured at LMC#1 is likely attributable to the many seeps and drainages found along the MC#1 drainage, and documented during a walk along the drainage in August, 2004. There is progressive increase in flows found at LMC#1 throughout the irrigation season. This indicates progressively increasing contributions of water from surface runoff, return flows, and drainage water resulting from deep seepage.

Figure 4 is a plot of the average daily flows within the Tank Coulee drainage. Flows within Upper Tank Coulee (UTC) (green line), Middle Tank Coulee (MTC) (blue line), and Lower Tank Coulee (pink line) somewhat track each other. A large rainfall event is evident by the spike at all stations during June 2. According to the agrimet station located near Fairfield, 3.21 inches of precipitation was received between June 1-5.

A total of 5.52 inches of precipitation was received throughout the irrigation season. Of the two tributaries that contribute flow to Tank Coulee, Towers (red line) remains relatively stable with only very low flows throughout the season, but the tributary identified as Creek below GS 51 EXT does contribute a significant amount of flow to the system, and helps explain the increase in flow between MTC (blue line) and LTC (pink line). Additionally, as depicted in figure 2, GID reports a spill between UTC and MTC and a spill between MTC and LTC.

Figure 5 depicts daily flows measured or estimated at and above the Power gauging station. A large portion of flows had to be estimated at these stations due to equipment related problems. Monitoring stations are listed within the legend in the order they appear going upstream from Power. Cordova at Side Coulee (light blue line) and McAlpine (pink line) represent a single tributary (top and end) that discharges into Muddy Creek just above the Cordova station. Differences in flow between these two stations (1,134 acft – from figure 2) are a result of several small springs and runoff water coming in. Likewise, there is an increase in flow between Power (green line) and Cordova (navy blue line). GID doesn't report any spill water between these two stations. Figure 2 shows a calculation of 2,451 acft gain in flow between Power and Cordova during the irrigation season. Figure 2 indicates a loss of 1,967 acre feet of water between Cliev and Cordova, despite inflows of 418 acft from spill GM77, 584 acft from spill GM72, and 3,169 acft from Cordova at Coulee. One irrigator is known to be pumping 814 gallons/minute continuously throughout the irrigation season (353 acft). Between Lower Kloppel Coulee (brown line), which is identified as the beginning of Muddy Creek, and Cliev (purple line) there is a significant increase in flow.

With the assistance from GID management, efforts were undertaken to partition monitored flows for each flow segment of this project for: 1) operational spills and wasteway contributions, 2) baseflow (a source of perennial flow), and 3) farm field sources, consisting of return flows, fields spills, and seepage. Data collected were used to develop Table 2.

Table 2. Summary - 2005 Flow Sources and Contributions to MC tributary #1, Tank Coulee and Muddy Creek above Power for May 14 – August 20, 2005. All values reported in acre feet.

Tributary/ Source	Operational spills/ wasteways	Baseflow	Tribs	Farm field sources – return flows, seepage	Diversion Losses	Total gauged flow
MC#1	1,642	567	501	107	none	2,817
Tank Coulee	224	897	2,860	5,930	none	9,911
Above Power	1,631	1,882	3,169	1,497	1,967	6,212

Sediment Patterns

Sediment amounts (loads) at the monitoring stations along Muddy Creek and tributaries were determined by applying daily flow data to sediment concentration correlations as functions of flow for each gauging and monitoring site. Flows x sediment curves were developed for each monitoring site (see Appendix tables). Combining daily flow velocities with associated sediment concentrations provided a mechanism for calculating sediment loads as a function of time. These amounts were then accumulated for the irrigation season. Figure 2 depicts flow and sediment recorded at each station during the irrigation season in order along the stream channel. Boxes between stations show gains and losses in flow and sediment. Gains and losses in flow are identified in red and with + symbols for gains and – symbols for losses. Gains in sediment are identified in brown and with + symbols (there were no losses).

A total of 1,142 tons of sediment was contributed from Muddy Creek tributary #1 to Muddy Creek. Of that, 1,111 tons of sediment was gained between the upper and lower portions. Flow measured at LMC#1 had the largest sediment concentrations per acre foot of water – 0.41 tons/acre foot. During the 2004 scoping walk, several high sloping erosive banks were identified which could of definitely contributed to the sediment loads measured.

Tank Coulee contributed 1,253 tons of sediment to Muddy Creek. Figure 2 shows the majority of sediment was sourced between the Middle Tank Coulee gauge and the Lower Tank Coulee gauge. This sediment gain coincides with a relatively large flow addition between these two gauging stations.

Figure 2 shows that 637 tons of sediment passed by the Muddy Creek at Power gauging station. The largest gains in sediment above Power were not measured within the Muddy Creek channel, but in the tributary reach between McAlpine and Cordova at Side Coulee. GID reports that there is a significant amount of runoff water and springs coming in between these two stations. Insignificant amounts of sediment are gained between the Cordova and Power gauging stations. The largest source of sediment within Muddy Creek proper above Power is found between the Cliev and Cordova gauging stations. Table 1 shows that Cordova averaged 0.17 tons of sediment/acre foot of water during the irrigation season. 409 tons of sediment was gained between these two stations.

A look back at the 2003 study completed by MSU shows that sediment loads were less in 2005 in Tank Coulee and in Muddy Creek at Power. Yet, sediment loads measured at Muddy Creek tributary #1 were significantly greater.

Summary

Flow and sediment were monitored at sixteen sites within three portions of the Muddy Creek drainage – Muddy Creek tributary #1, Tank Coulee, and above Power.

Three stations were monitored throughout Muddy Creek tributary #1. Gauged flow at LMC#1 was portioned out into several categories – baseflow, operational spills, farm field wastes, and tributary flows. All gains in flow within MC#1 are understood. 1,142 tons of sediment were measured at the LMC#1 gauging station. Notes from the August 2004 scoping trip identify several key areas where sediment was likely sourced, and areas where work could easily be done to reduce sediment loads.

On Tank Coulee, two new gauges were installed in addition to the gauges previously in place during the 2003 study. The gauge at Creek below GS 51 EXT helped to explain part of the large increases in flow between Middle and Lower Tank Coulee. The study also found that a large portion of the sediment measured in Tank Coulee is sourced between the MTC and LTC gauging stations. Any efforts to reduce sediment loads should be focused on this area of Tank Coulee.

Seven stations located at and above Power helped identify flow and sediment sources. A large portion of flow and sediment coming into Power is sourced from a tributary just upstream of Cordova, identified in this study as Cordova at Side Coulee and McAlpine. From this study it is apparent that sediment loads at the headworks of Muddy Creek are very small.

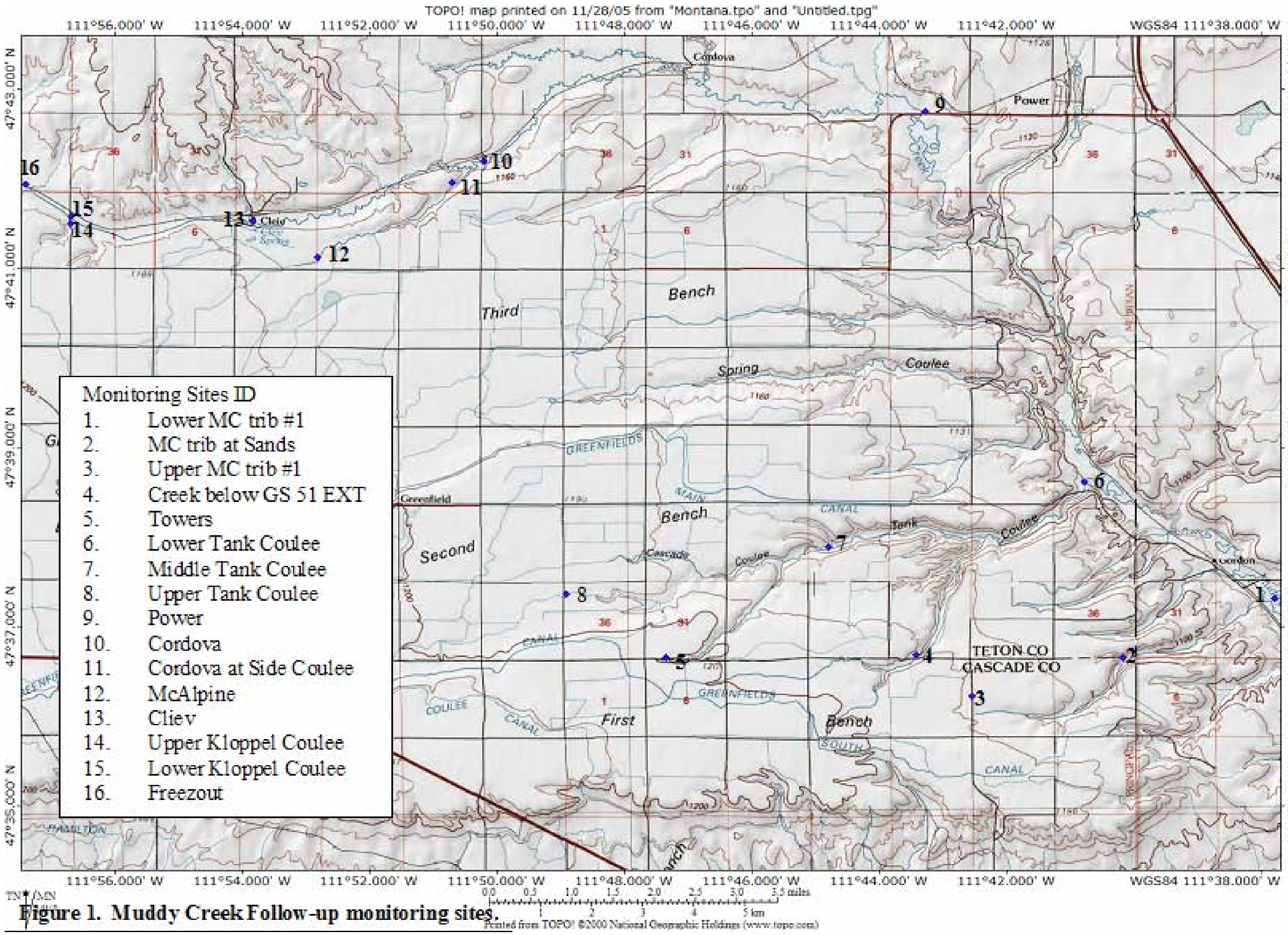


Figure 1. Muddy Creek Follow-up monitoring sites.

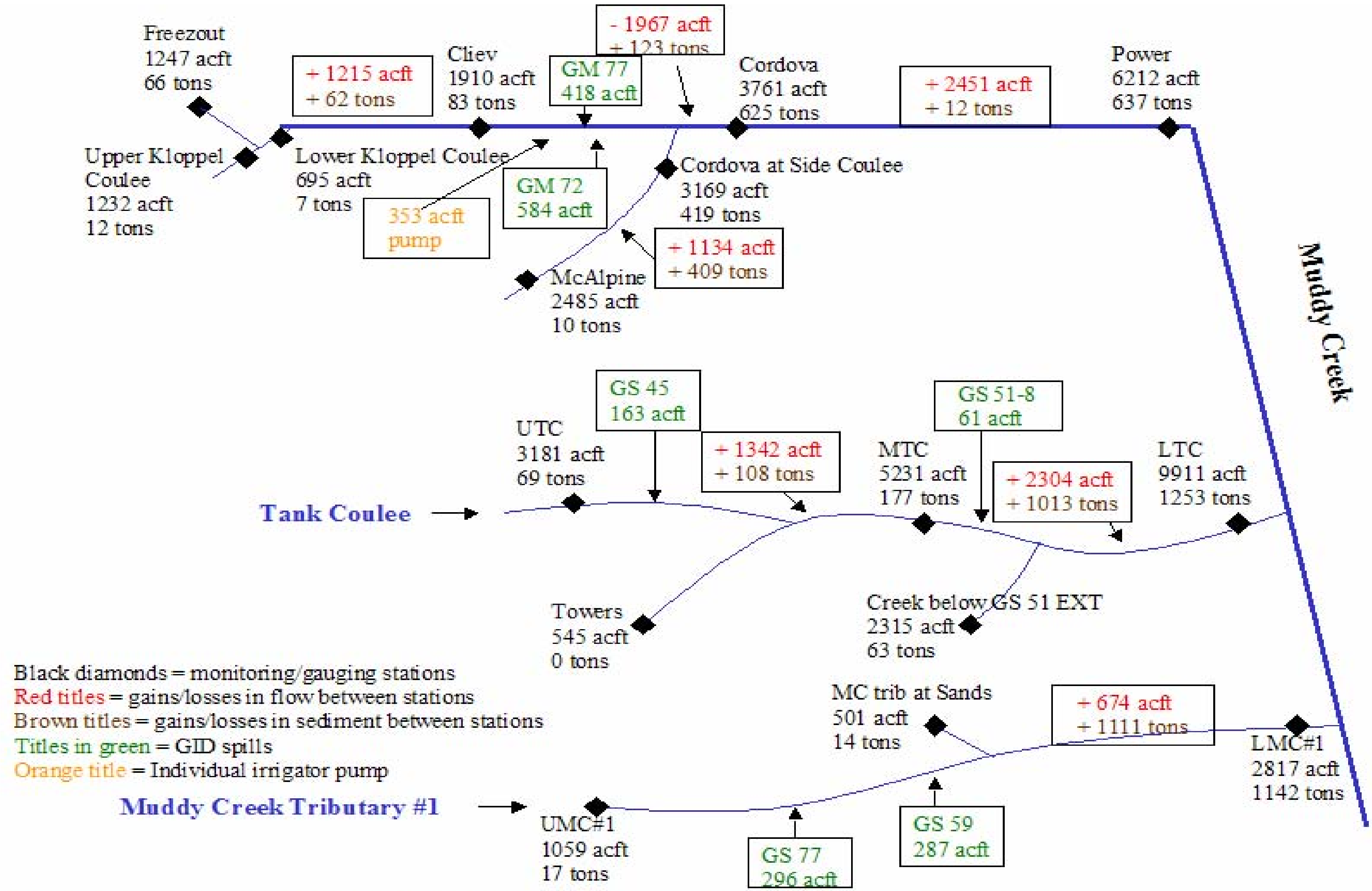


Figure 2. Flow and sediment calculations with GID spills and gains and losses in sediment and flows for Muddy Creek tributaries.

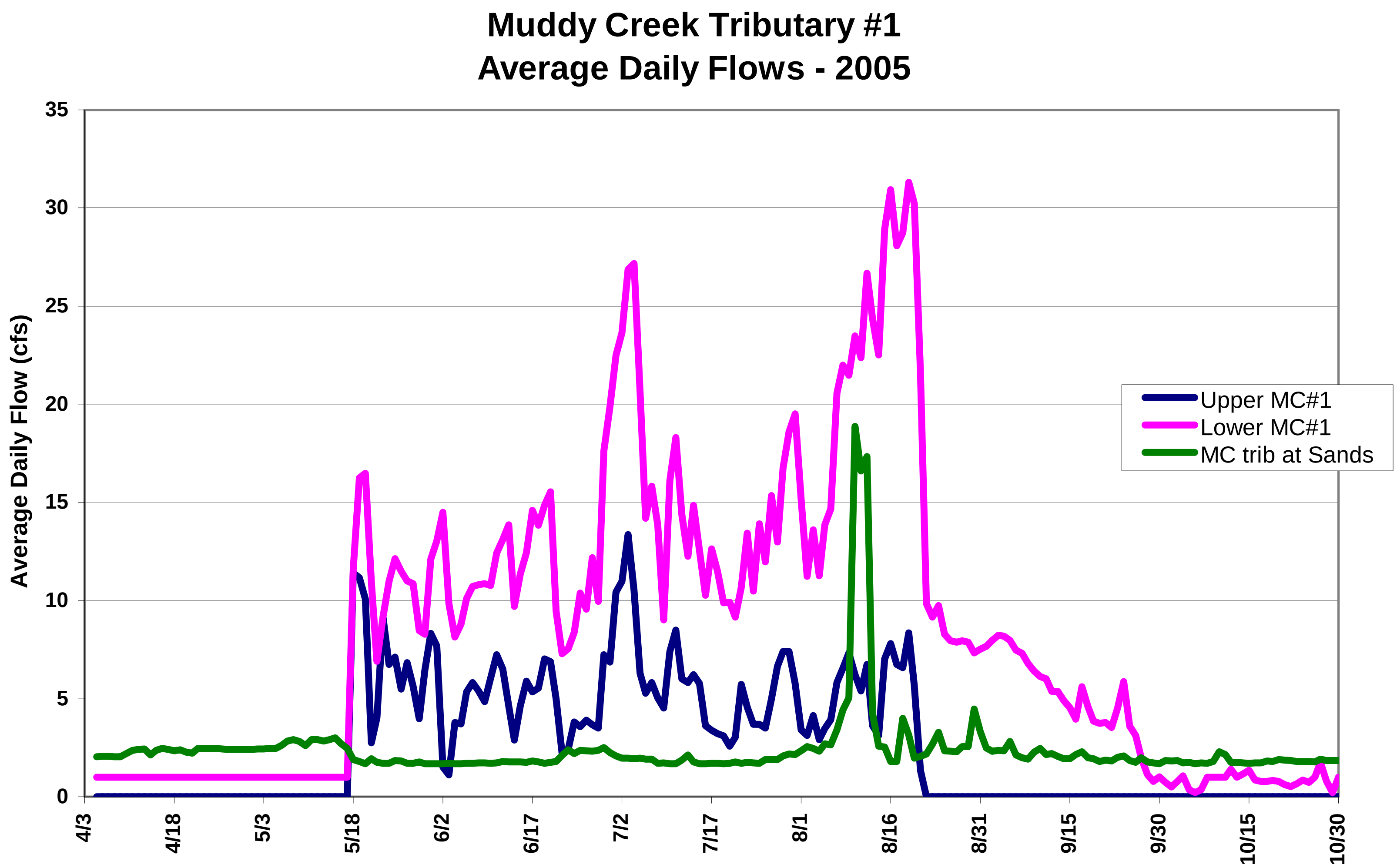


Figure 3. Average Daily flows measured at Upper MC#1, Lower MC#1, and tributary to MC#1 (MC trib at Sands).

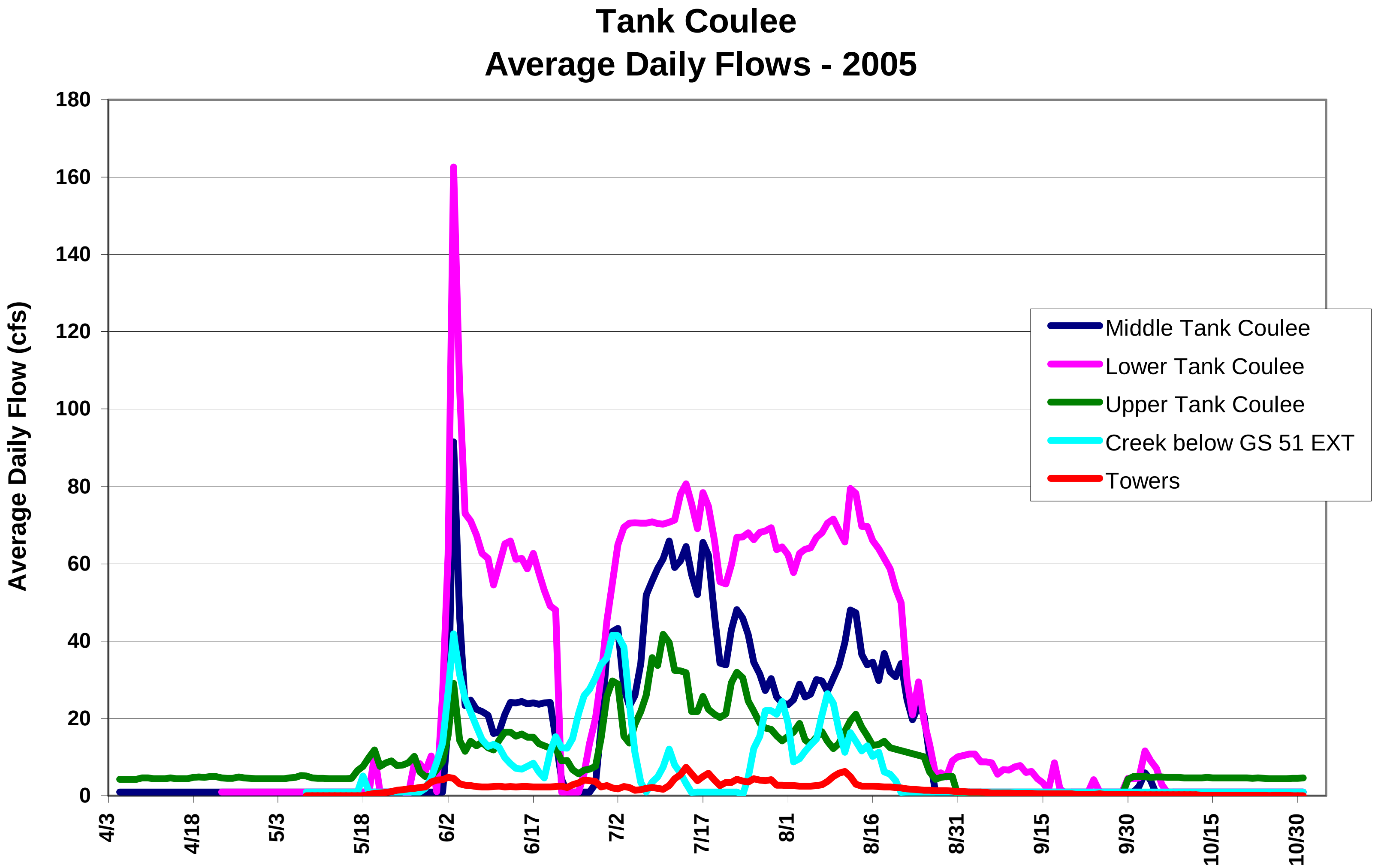


Figure 4. Average daily flows measured within the Tank Coulee drainage.

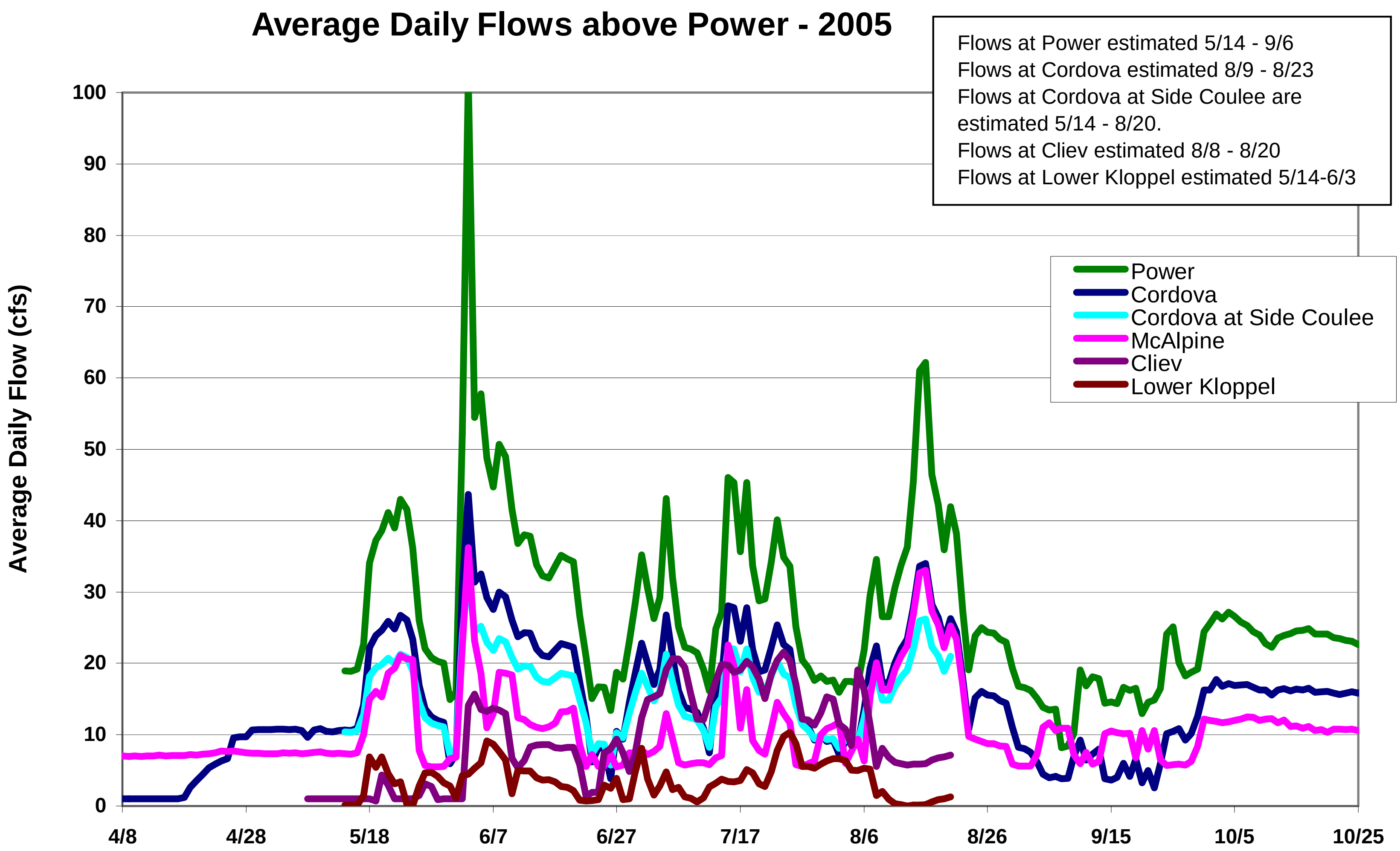


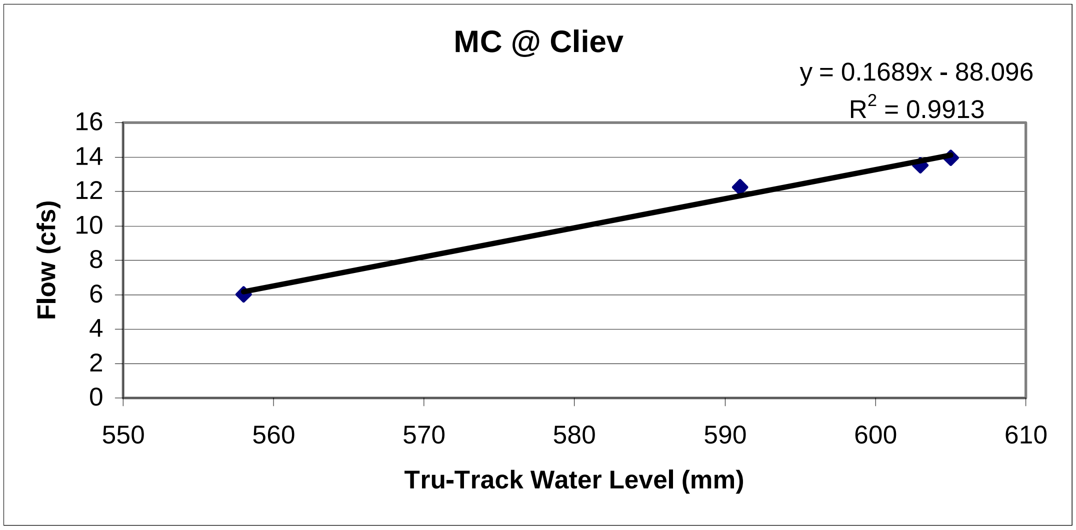
Figure 5. Average daily flows measured/estimated at and above the Power gauging station.

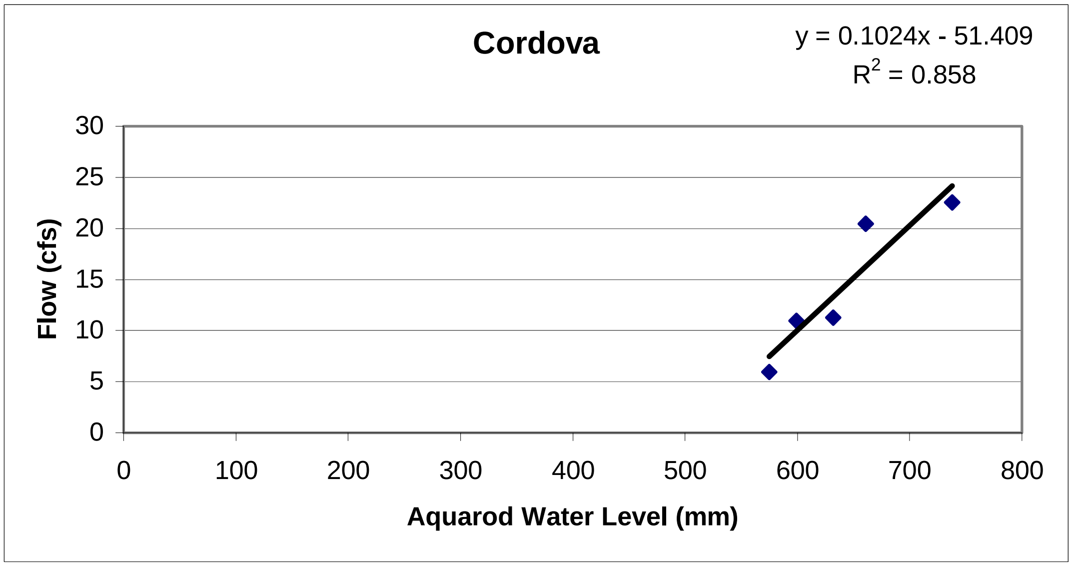
APPENDICES

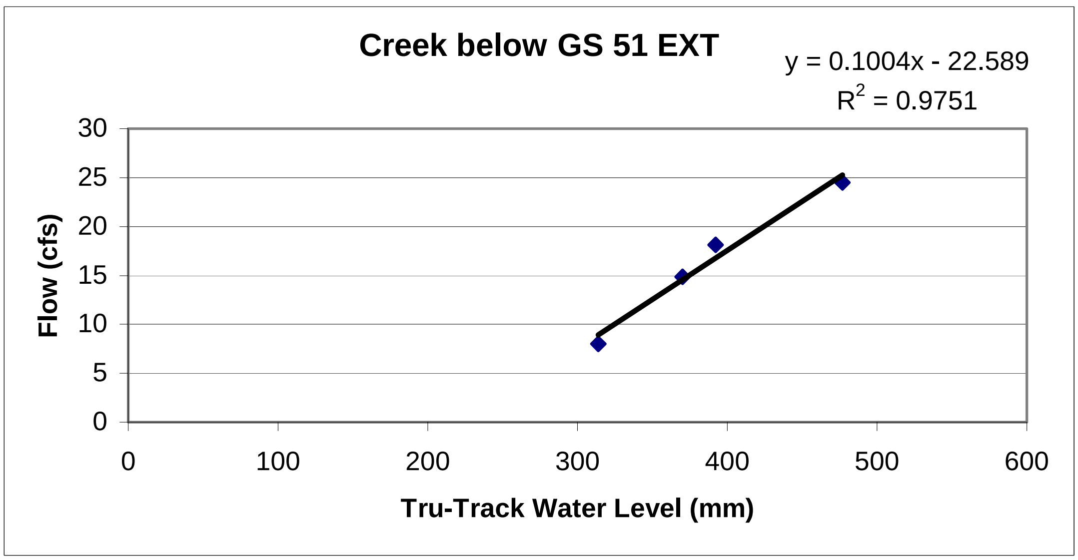
AQUAROD/TRU-TRACK RATING CURVES
STAFF GAUGE RATING CURVES
SEDIMENT X FLOW CORRELATIONS

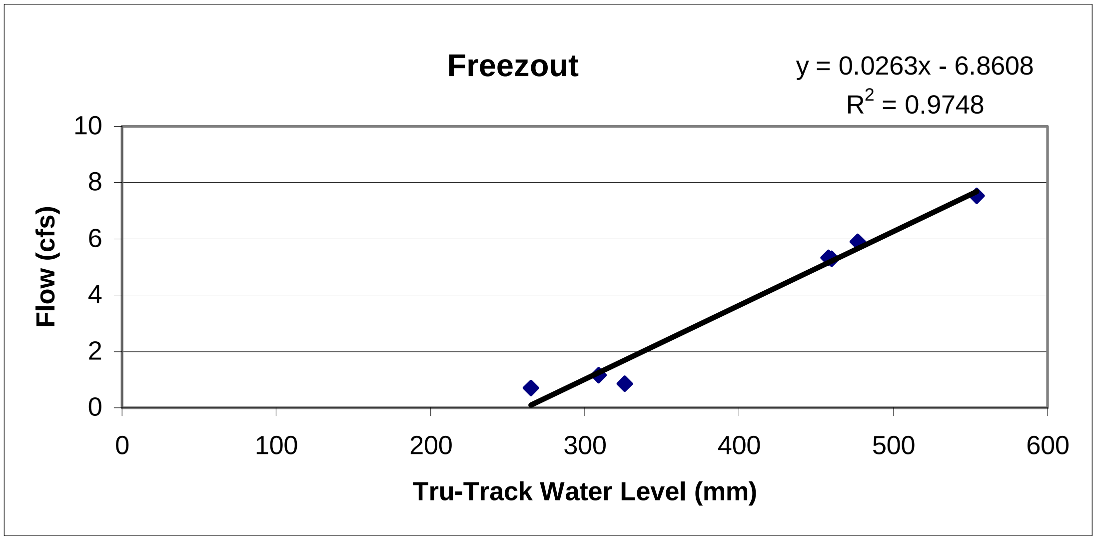
Muddy Creek at Power – June 3, 2005

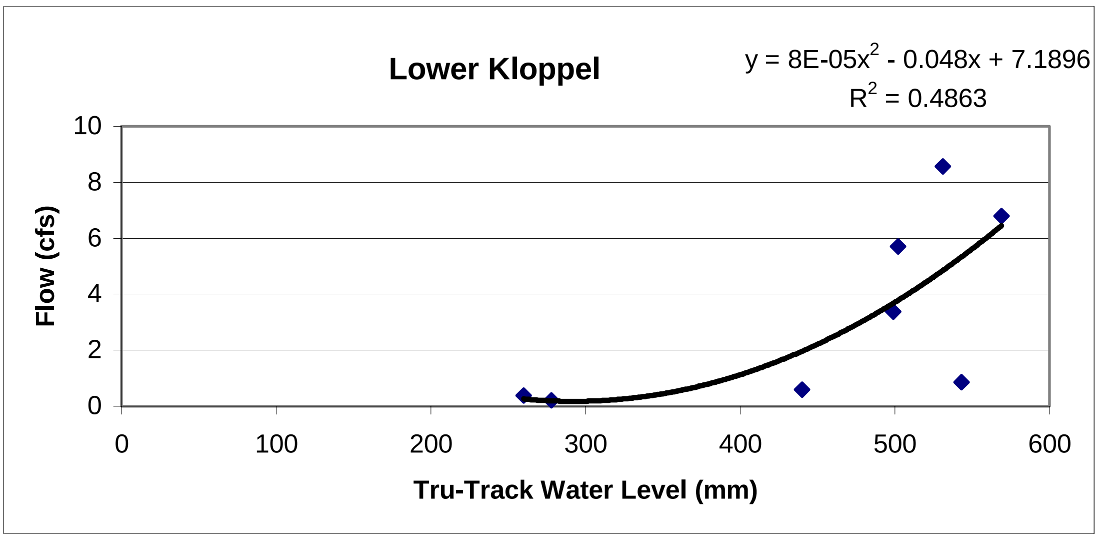
Creek below GS 51 EXT – May 31, 2005

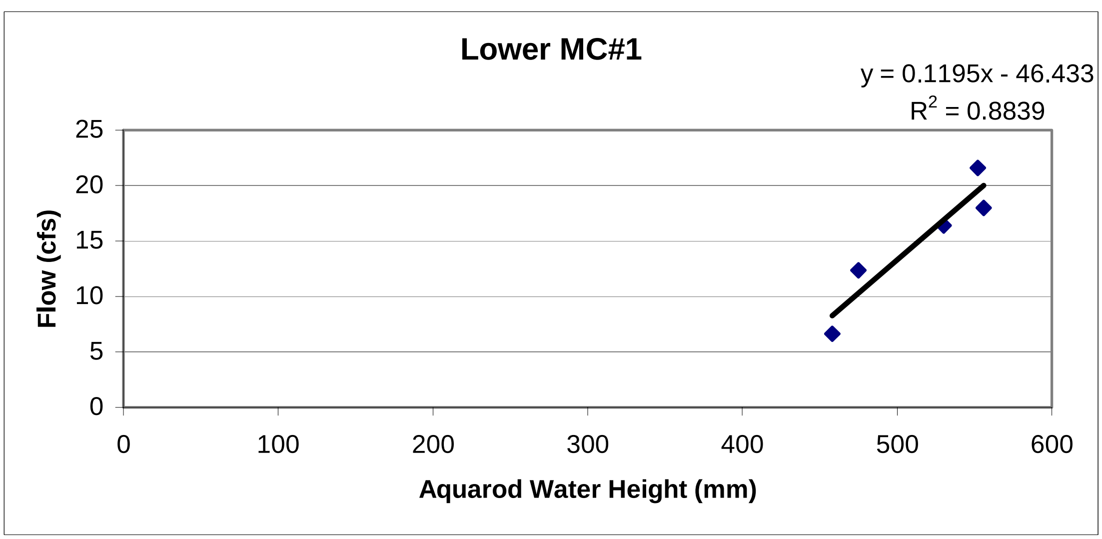

MC @ Cliev
y = 0.1689x - 88.096
R2 = 0.9913
Flow (cfs)
16
14
12
10
8
6
4
2
0
550
560
570
580
590
600
610
Tru-Track Water Level (mm)

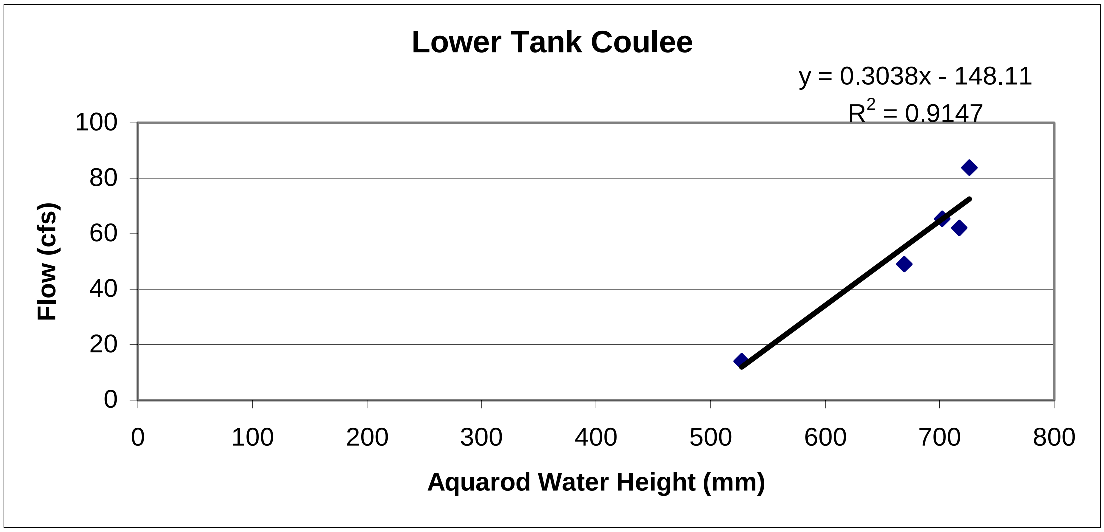

Cordova
y = 0.1024x - 51.409
R2 = 0.858
Flow (cfs)
30
25
20
15
10
5
0
0
100
200
300
400
500
600
700
800
Aquarod Water Level (mm)

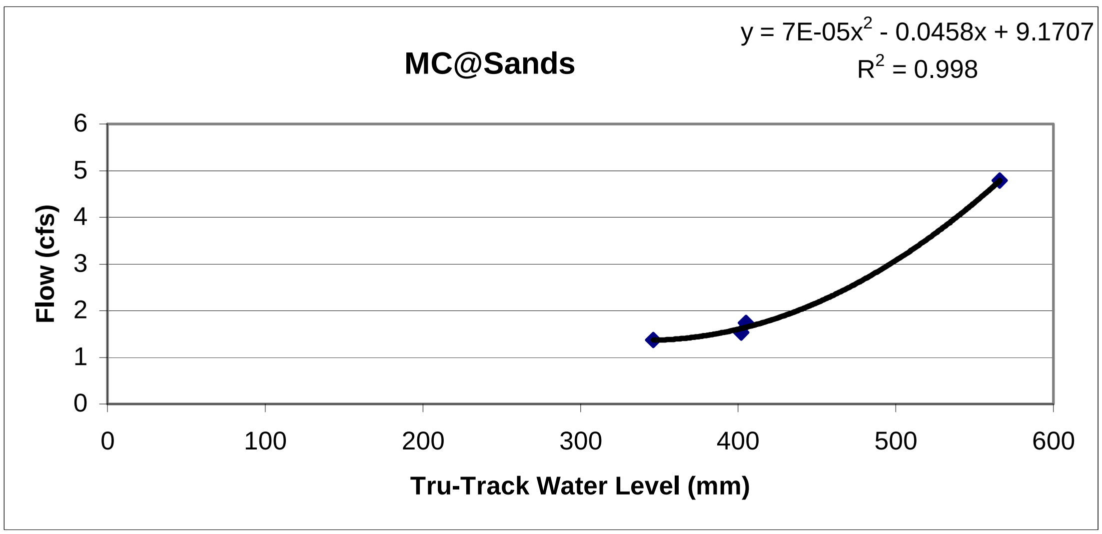

Creek below GS 51 EXT
y = 0.1004x - 22.589
R2 = 0.9751
Flow (cfs)
30
25
20
15
10
5
0
0
100
200
300
400
500
600
Tru-Track Water Level (mm)

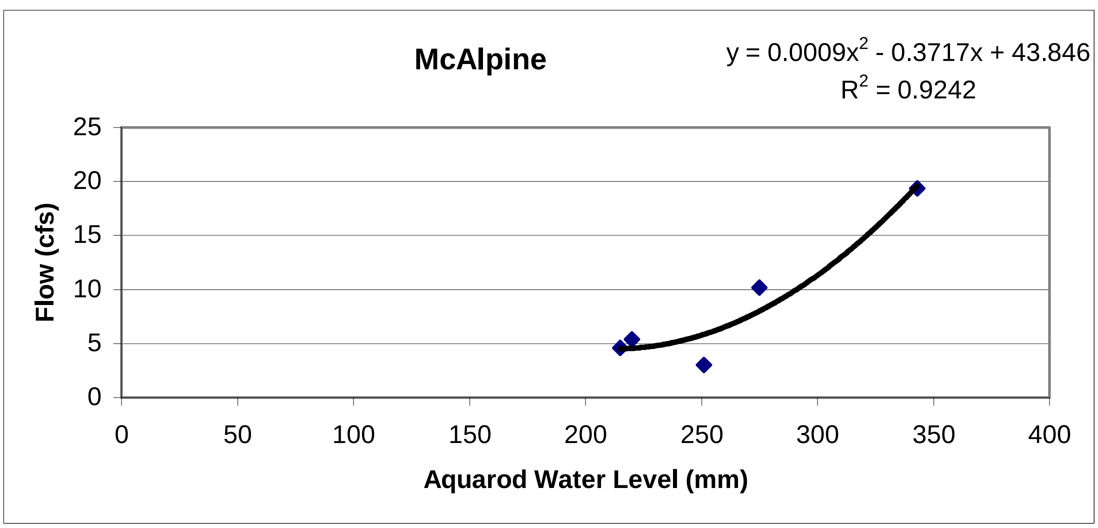

Freezout
y = 0.0263x - 6.8608
R2 = 0.9748
Flow (cfs)
0
2
4
6
8
10
0
100
200
300
400
500
600
Tru-Track Water Level (mm)

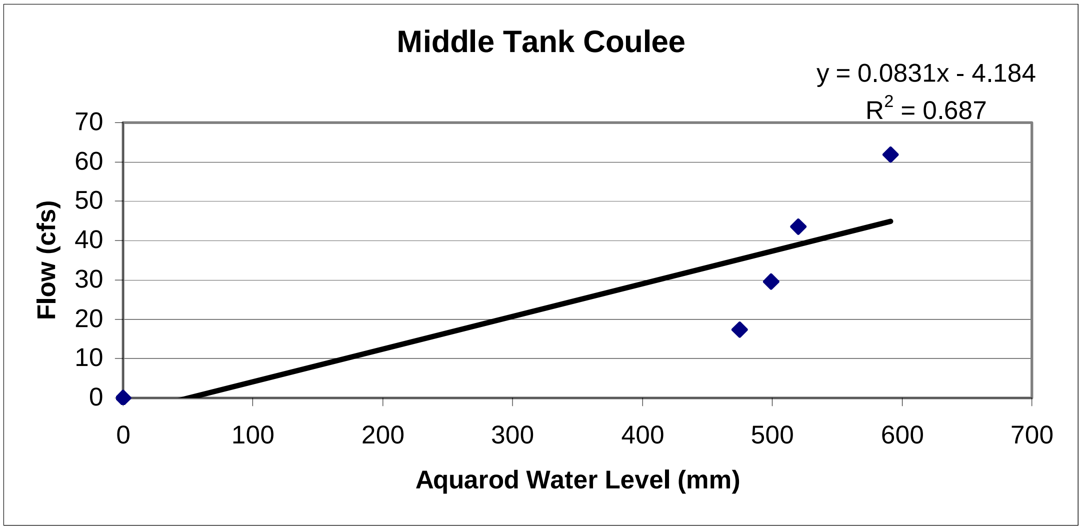

Lower Kloppel
y = 8E-05x2 - 0.048x + 7.1896
R2 = 0.4863
Flow (cfs)
0
2
4
6
8
10
0
100
200
300
400
500
600
Tru-Track Water Level (mm)

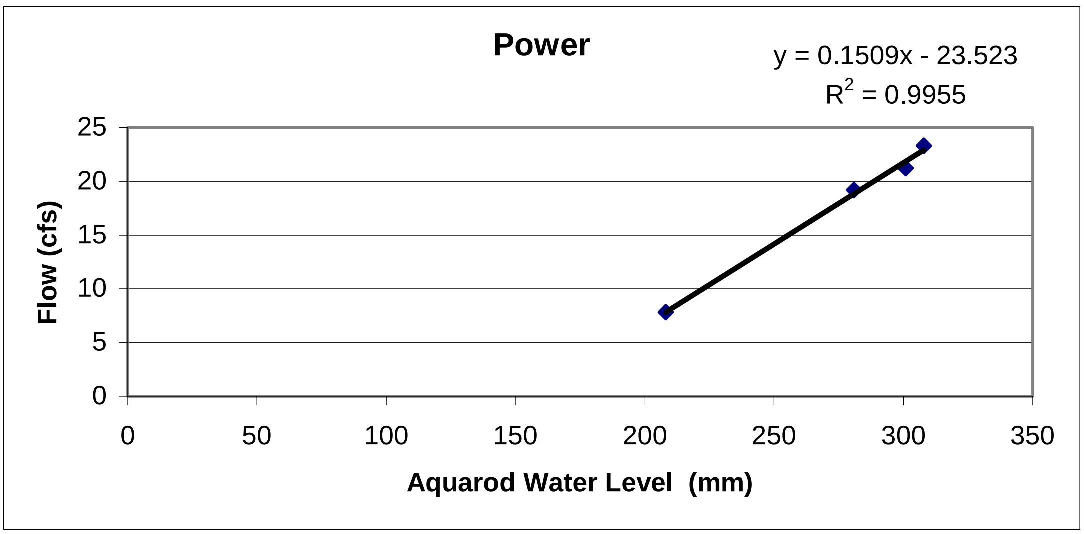

Lower MC#1
y = 0.1195x - 46.433
R2 = 0.8839
Flow (cfs)
0
5
10
15
20
25
0
100
200
300
400
500
600
Aquarod Water Height (mm)

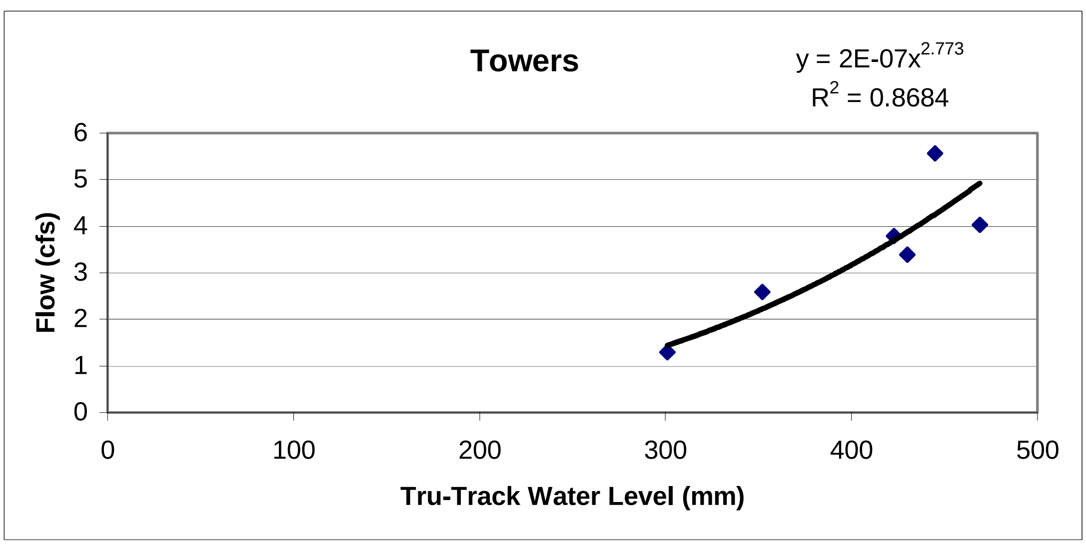

Lower Tank Coulee
y = 0.3038x - 148.11
R2 = 0.9147
Flow (cfs)
Aquarod Water Height (mm)
100
80
60
40
20
0
0
100
200
300
400
500
600
700
800

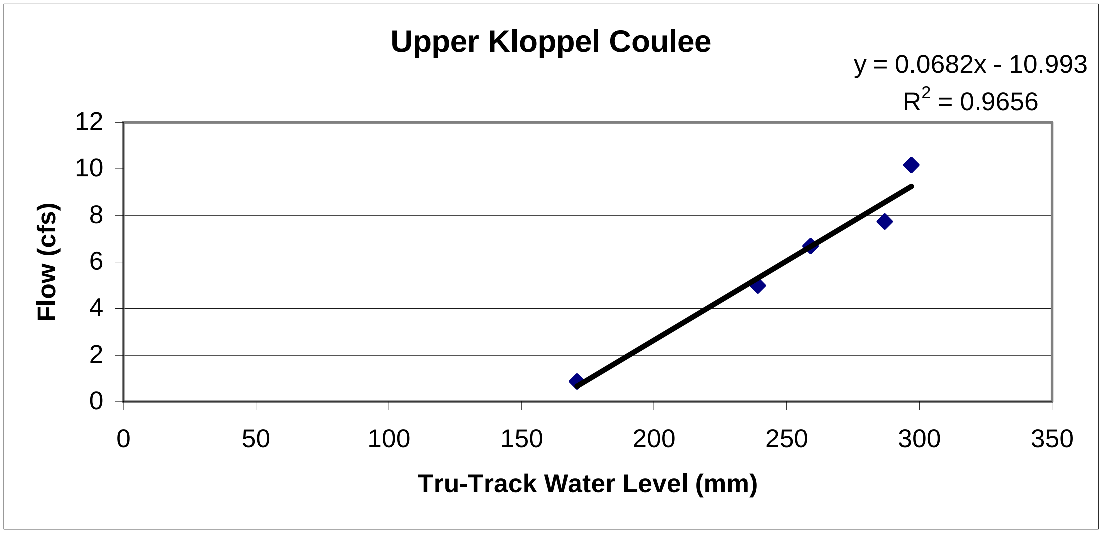

MC@Sands
y = 7E-05x2 - 0.0458x + 9.1707
R2 = 0.998
Flow (cfs)
Tru-Track Water Level (mm)
6
5
4
3
2
1
0
0
100
200
300
400
500
600

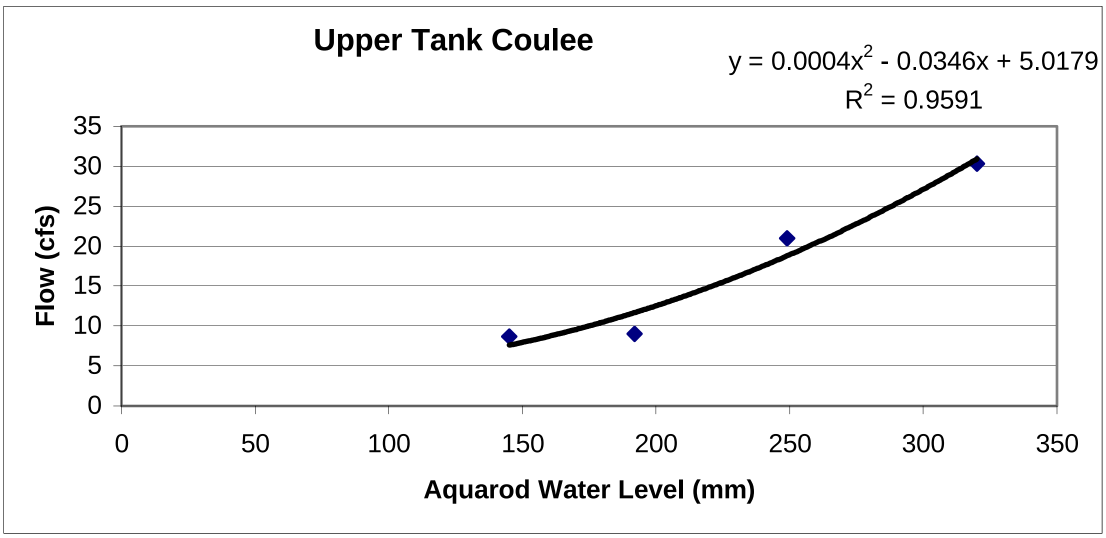

McAlpine
y = 0.0009x2 - 0.3717x + 43.846
R2 = 0.9242
Flow (cfs)
Aquarod Water Level (mm)
25
20
15
10
5
0
0
50
100
150
200
250
300
350
400

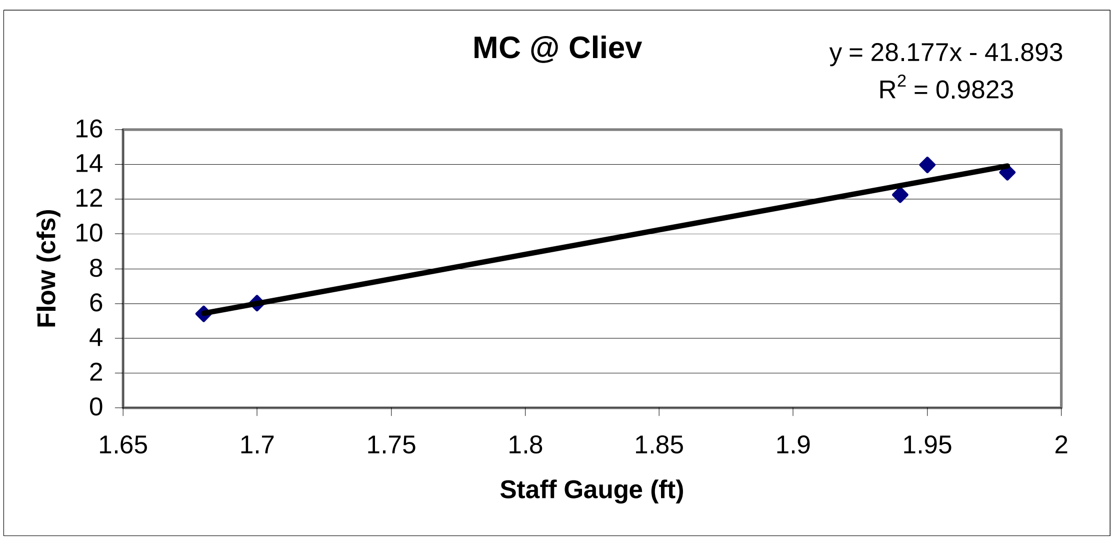

Middle Tank Coulee
y = 0.0831x - 4.184
R2 = 0.687
Flow (cfs)
Aquarod Water Level (mm)
0
10
20
30
40
50
60
70
0
100
200
300
400
500
600
700

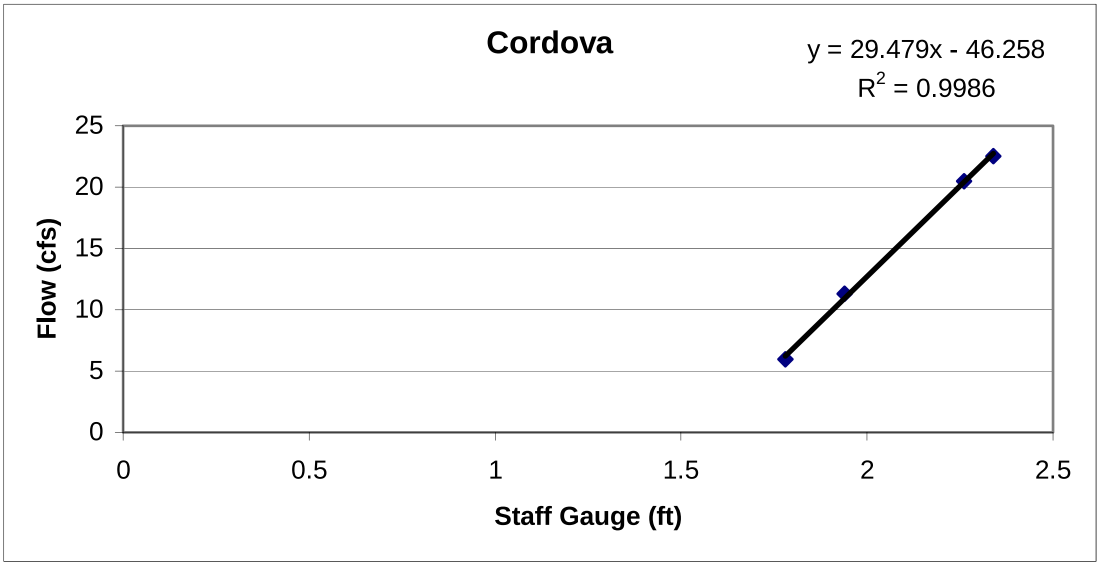

Power
y = 0.1509x - 23.523
R2 = 0.9955
Flow (cfs)
Aquarod Water Level (mm)
0
5
10
15
20
25
0
50
100
150
200
250
300
350

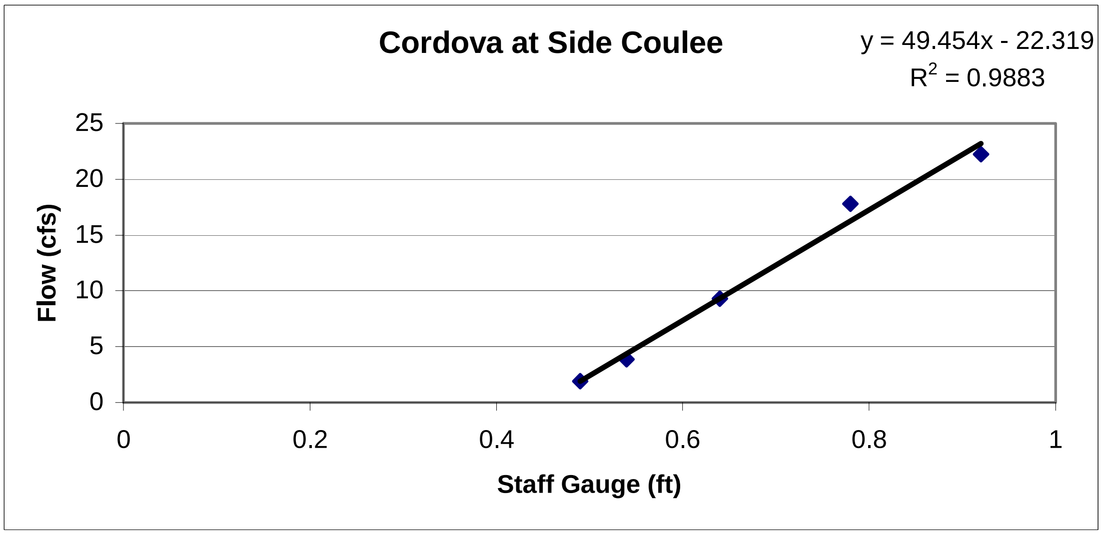

Towers
y = 2E-07x2.773
R2 = 0.8684
Flow (cfs)
Tru-Track Water Level (mm)
0
1
2
3
4
5
6
0
100
200
300
400
500

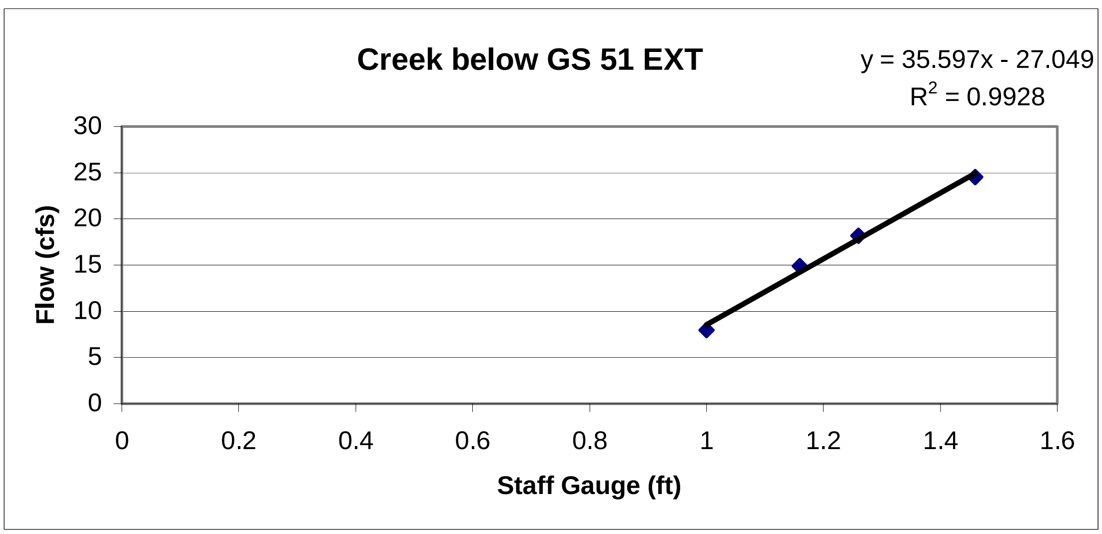

Upper Kloppel Coulee
y = 0.0682x - 10.993
R2 = 0.9656
Flow (cfs)
0
2
4
6
8
10
12
0
50
100
150
200
250
300
350
Tru-Track Water Level (mm)

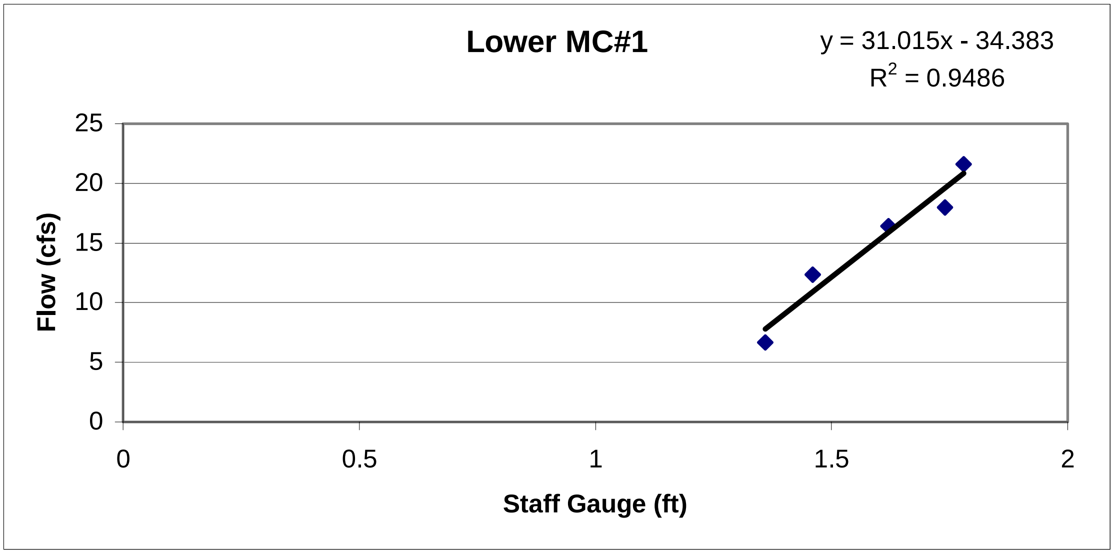

Upper Tank Coulee
y = 0.0004x2 - 0.0346x + 5.0179
R2 = 0.9591
Flow (cfs)
0
5
10
15
20
25
30
35
0
50
100
150
200
250
300
350
Aquarod Water Level (mm)

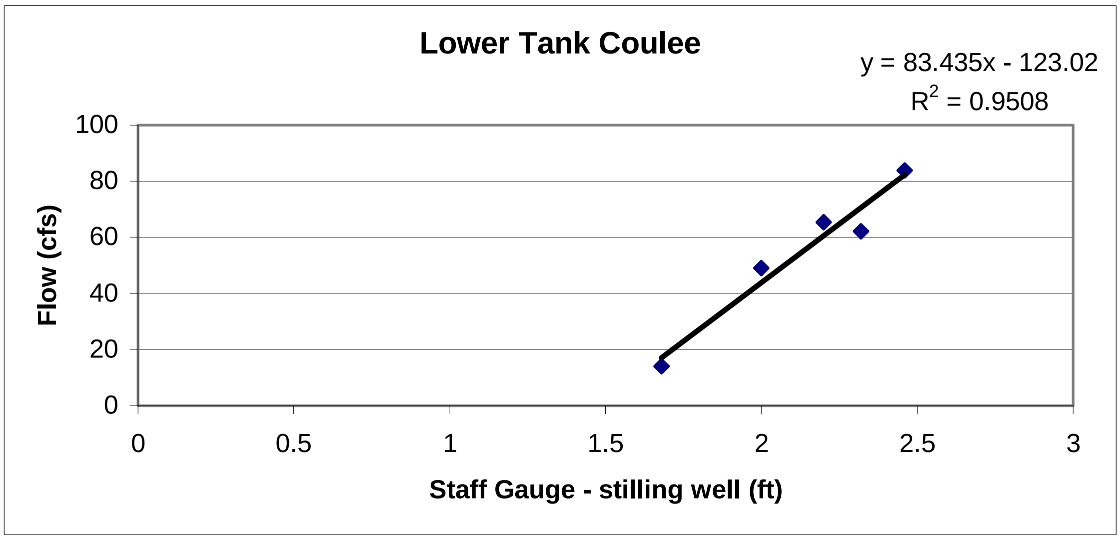

MC @ Cliev
y = 28.177x - 41.893
R2 = 0.9823
Flow (cfs)
0
2
4
6
8
10
12
14
16
1.65
1.7
1.75
1.8
1.85
1.9
1.95
2
Staff Gauge (ft)

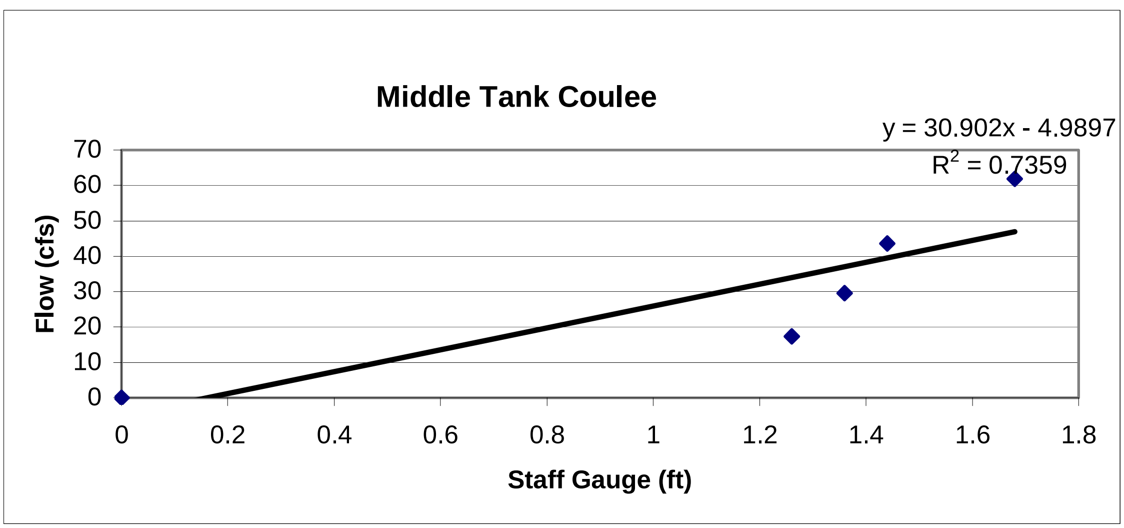

Cordova
y = 29.479x - 46.258
R^2 = 0.9986
25
20
15
10
5
0
Flow (cfs)
0
0.5
1
1.5
2
2.5
Staff Gauge (ft)

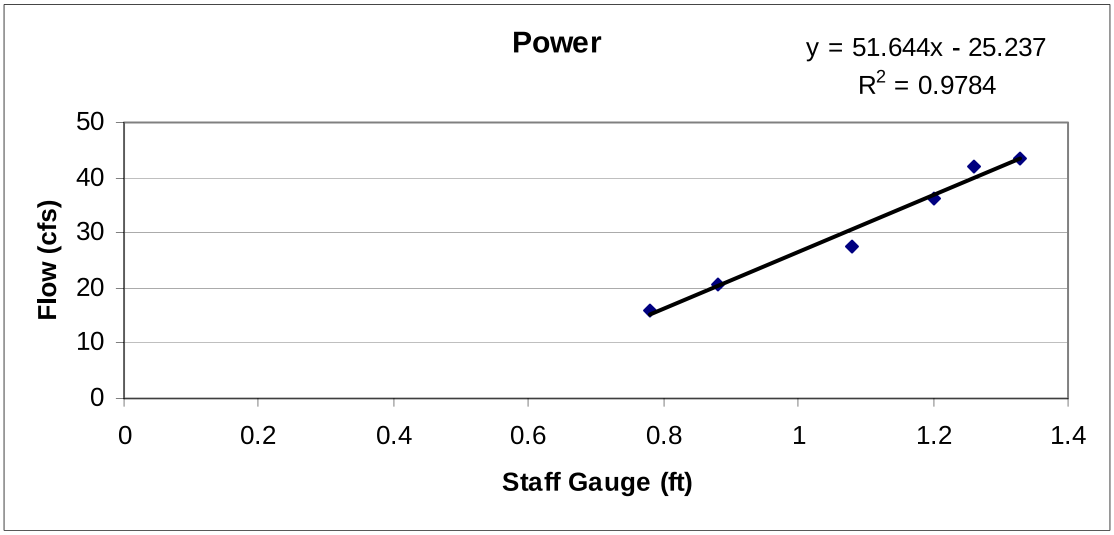

Cordova at Side Coulee
y = 49.454x - 22.319
R^2 = 0.9883
25
20
15
10
5
0
Flow (cfs)
0
0.2
0.4
0.6
0.8
1
Staff Gauge (ft)

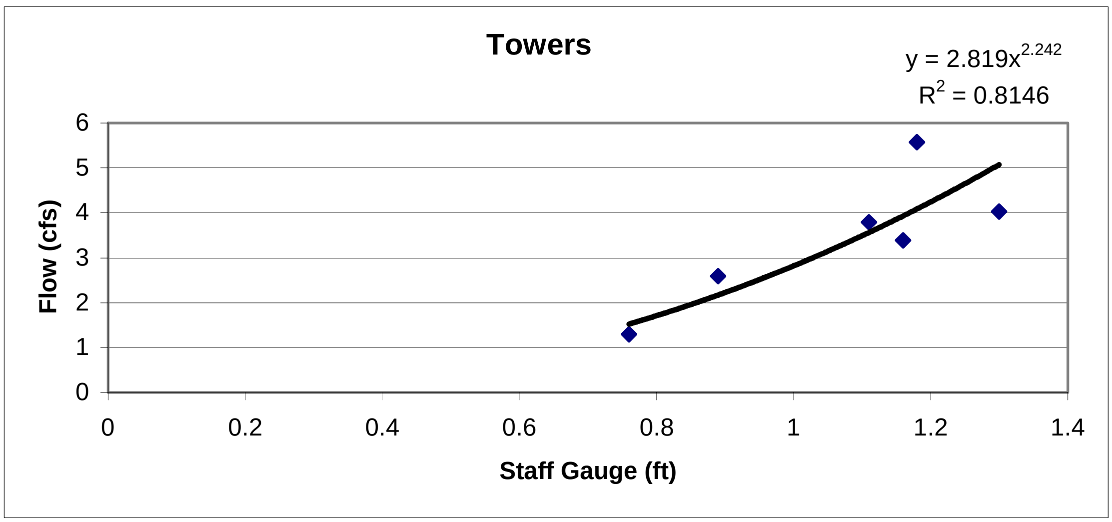

Creek below GS 51 EXT
y = 35.597x - 27.049
R^2 = 0.9928
30
25
20
15
10
5
0
Flow (cfs)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
Staff Gauge (ft)

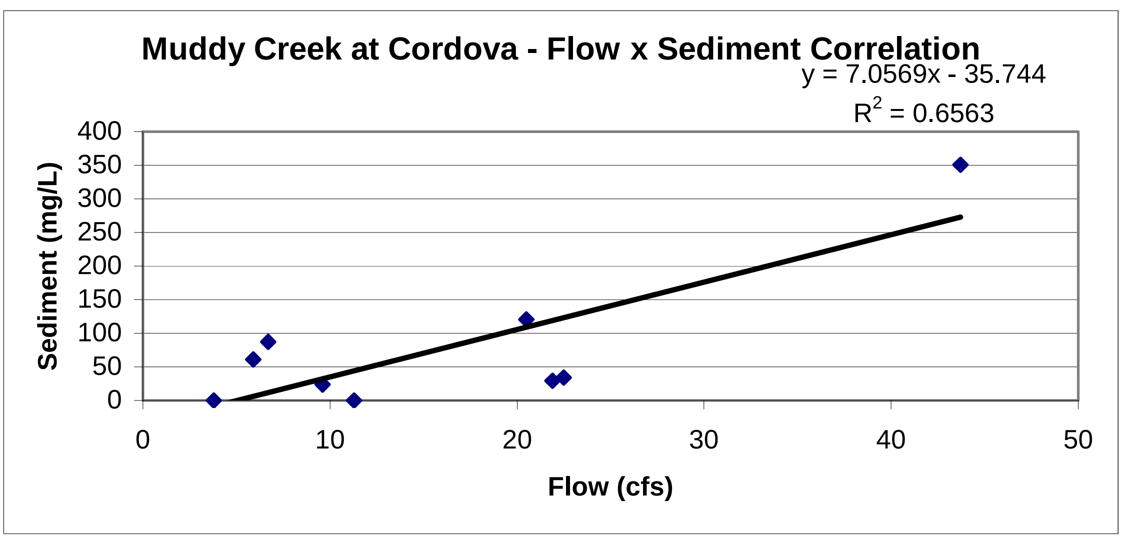

Lower MC#1
y = 31.015x - 34.383
R2 = 0.9486
Flow (cfs)
25
20
15
10
5
0
0
0.5
1
1.5
2
Staff Gauge (ft)

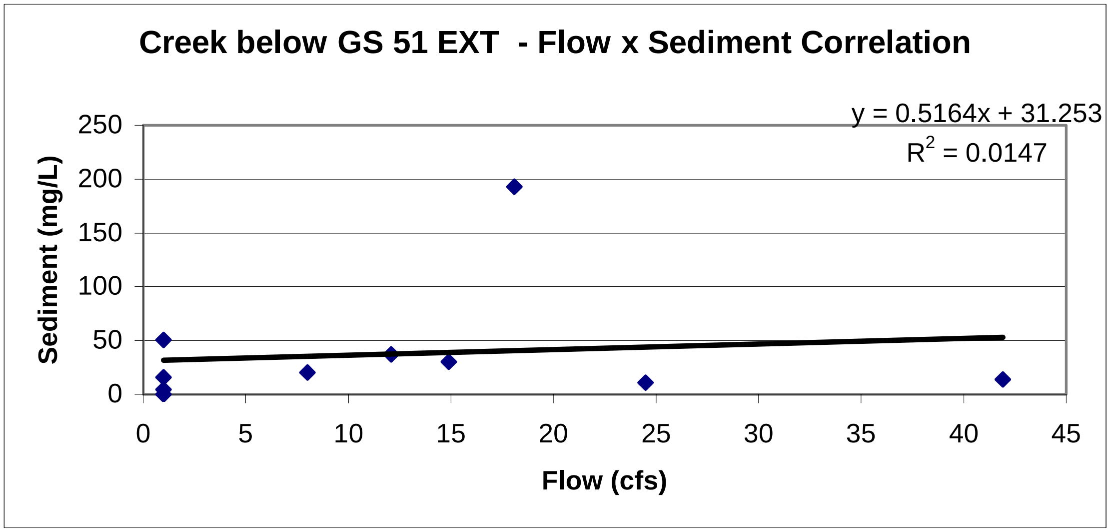

Lower Tank Coulee
y = 83.435x - 123.02
R2 = 0.9508
Flow (cfs)
100
80
60
40
20
0
0
0.5
1
1.5
2
2.5
3
Staff Gauge - stilling well (ft)

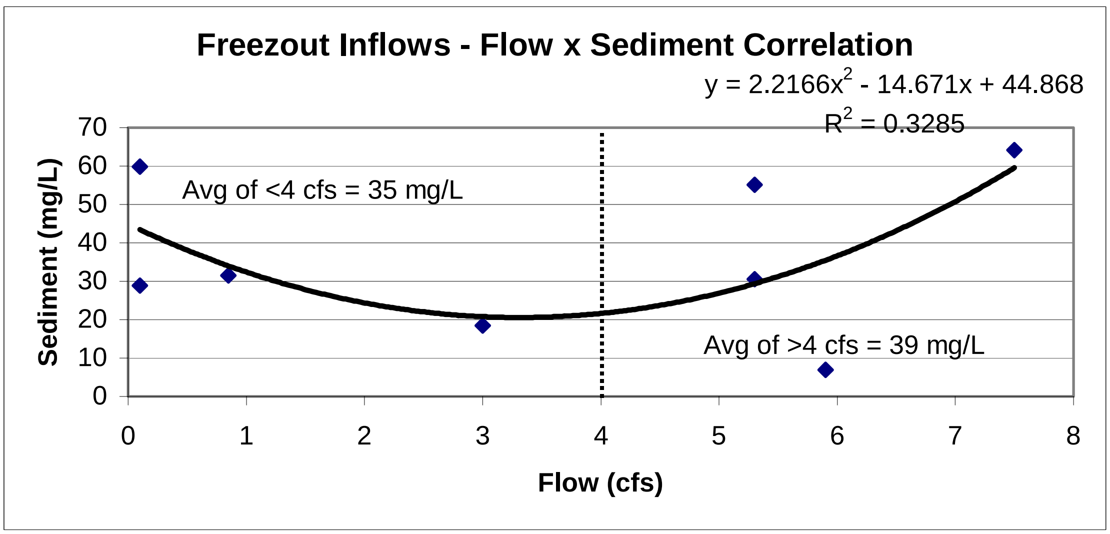

Middle Tank Coulee
y = 30.902x - 4.9897
R2 = 0.7359
Flow (cfs)
70
60
50
40
30
20
10
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
Staff Gauge (ft)

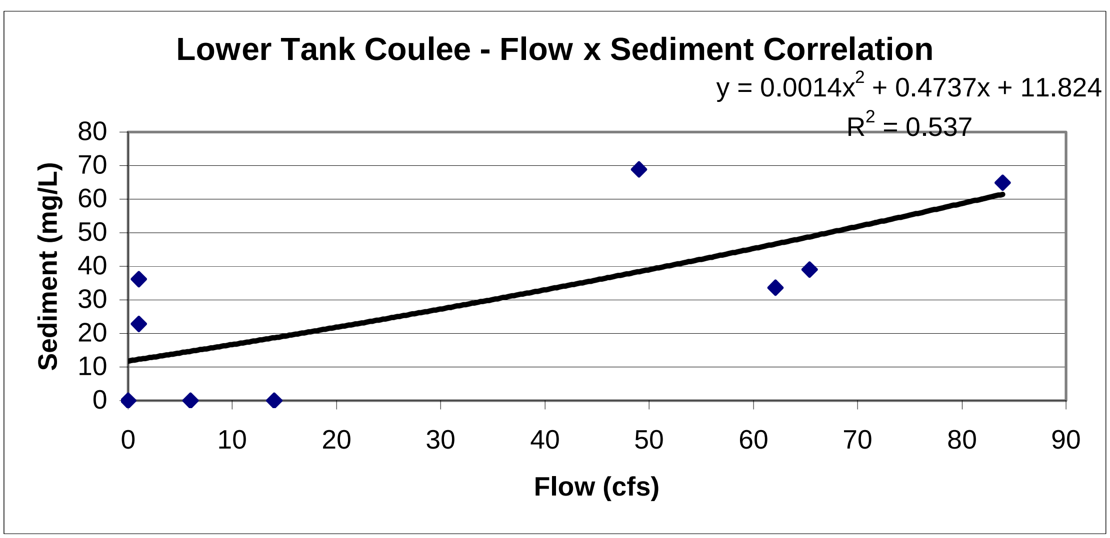

Power
y = 51.644x - 25.237
R2 = 0.9784
Flow (cfs)
50
40
30
20
10
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Staff Gauge (ft)

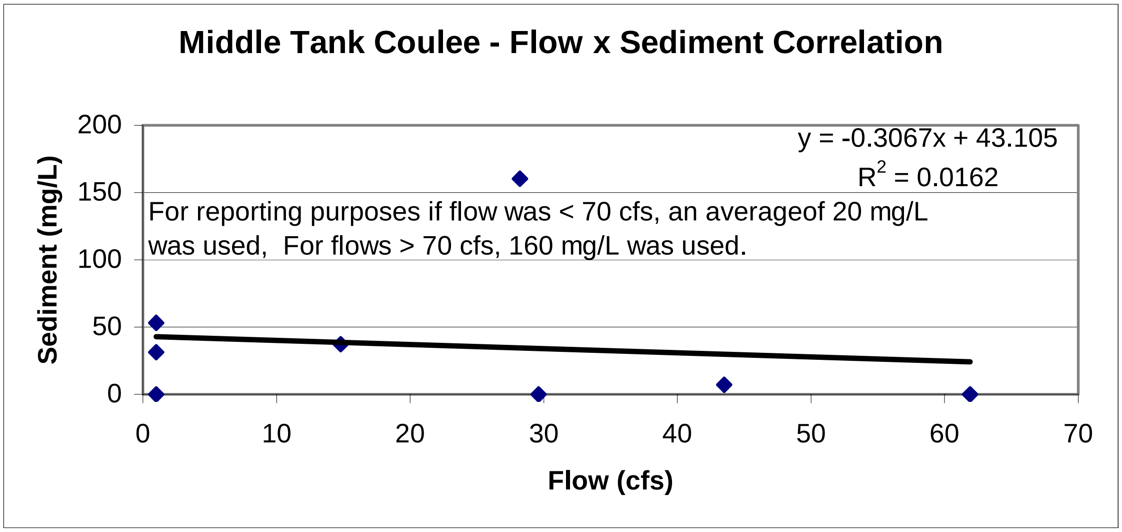

Towers
y = 2.819x2.242
R2 = 0.8146
Flow (cfs)
6
5
4
3
2
1
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Staff Gauge (ft)

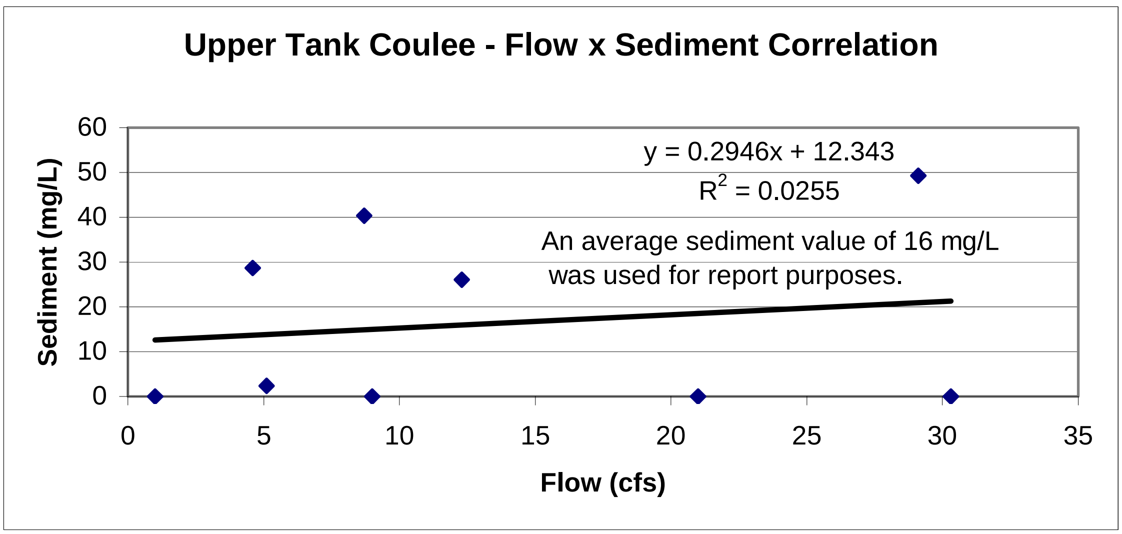

Muddy Creek at Cordova - Flow x Sediment Correlation
y = 7.0569x - 35.744
R2 = 0.6563
Sediment (mg/L)
400
350
300
250
200
150
100
50
0
0
10
20
30
40
50
Flow (cfs)

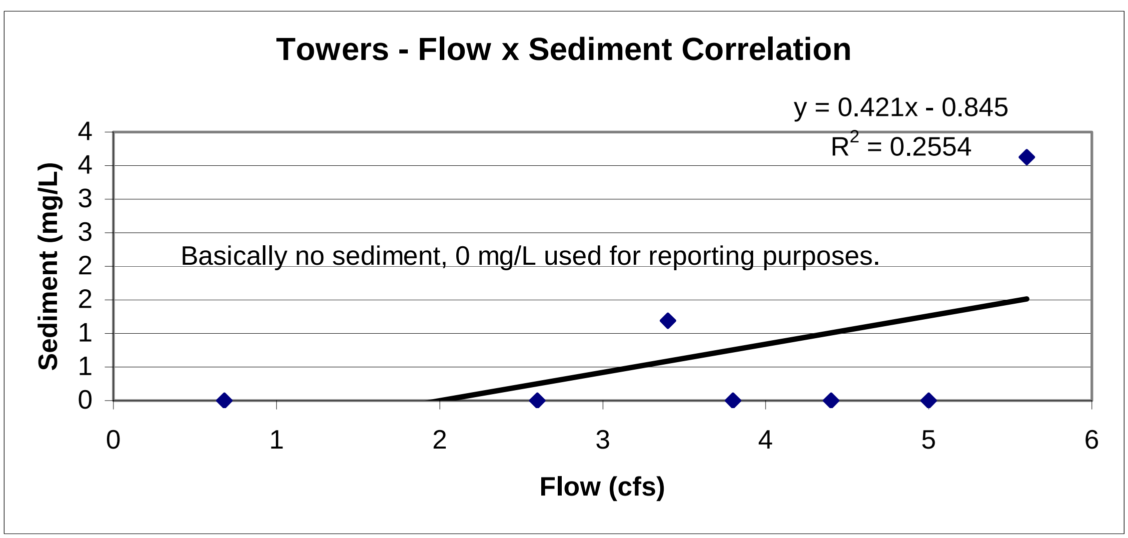

Creek below GS 51 EXT - Flow x Sediment Correlation
y = 0.5164x + 31.253
R2 = 0.0147
Sediment (mg/L)
0
50
100
150
200
250
0
5
10
15
20
25
30
35
40
45
Flow (cfs)

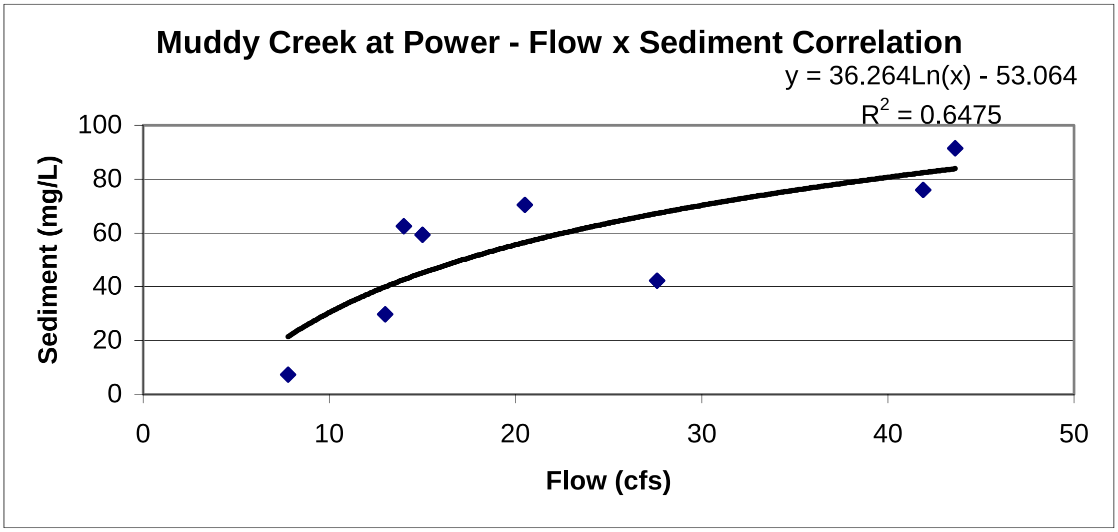

Freezout Inflows - Flow x Sediment Correlation
y = 2.2166x2 - 14.671x + 44.868
R2 = 0.3285
Avg of <4 cfs = 35 mg/L
Avg of >4 cfs = 39 mg/L
Sediment (mg/L)
0
10
20
30
40
50
60
70
0
1
2
3
4
5
6
7
8
Flow (cfs)


Lower Tank Coulee - Flow x Sediment Correlation
y = 0.0014x2 + 0.4737x + 11.824
R2 = 0.537
Sediment (mg/L)
0
10
20
30
40
50
60
70
80
0
10
20
30
40
50
60
70
80
90
Flow (cfs)

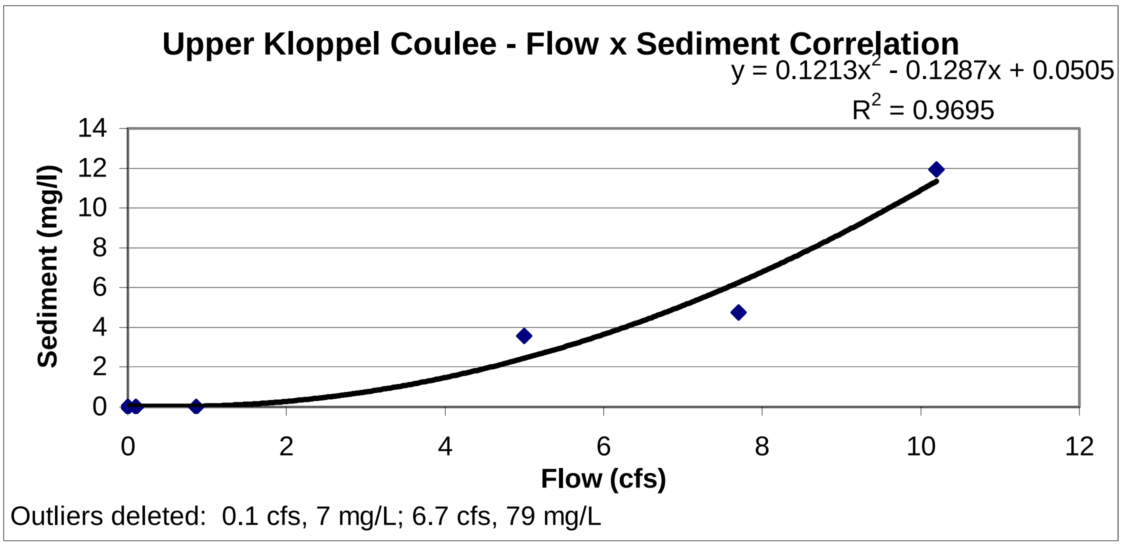

Middle Tank Coulee - Flow x Sediment Correlation
y = -0.3067x + 43.105
R2 = 0.0162
For reporting purposes if flow was < 70 cfs, an averageof 20 mg/L was used, For flows > 70 cfs, 160 mg/L was used.
Sediment (mg/L)
0
50
100
150
200
0
10
20
30
40
50
60
70
Flow (cfs)


Upper Tank Coulee - Flow x Sediment Correlation
y = 0.2946x + 12.343
R2 = 0.0255
An average sediment value of 16 mg/L was used for report purposes.
Sediment (mg/L)
0
10
20
30
40
50
60
0
5
10
15
20
25
30
35
Flow (cfs)

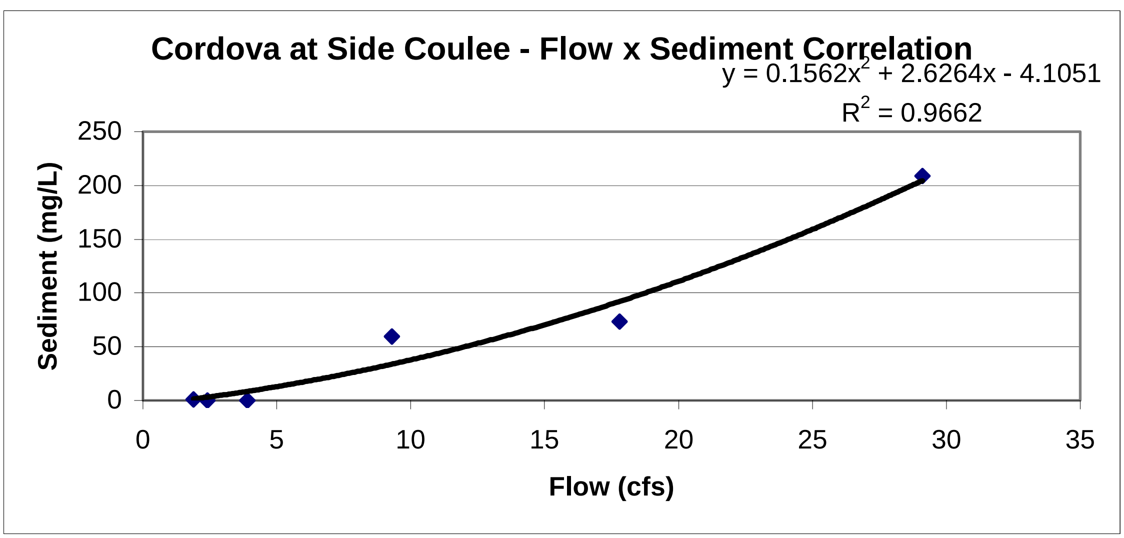

Towers - Flow x Sediment Correlation
y = 0.421x - 0.845
R2 = 0.2554
Basically no sediment, 0 mg/L used for reporting purposes.
Sediment (mg/L)
0
1
1
2
2
3
3
4
4
0
1
2
3
4
5
6
Flow (cfs)



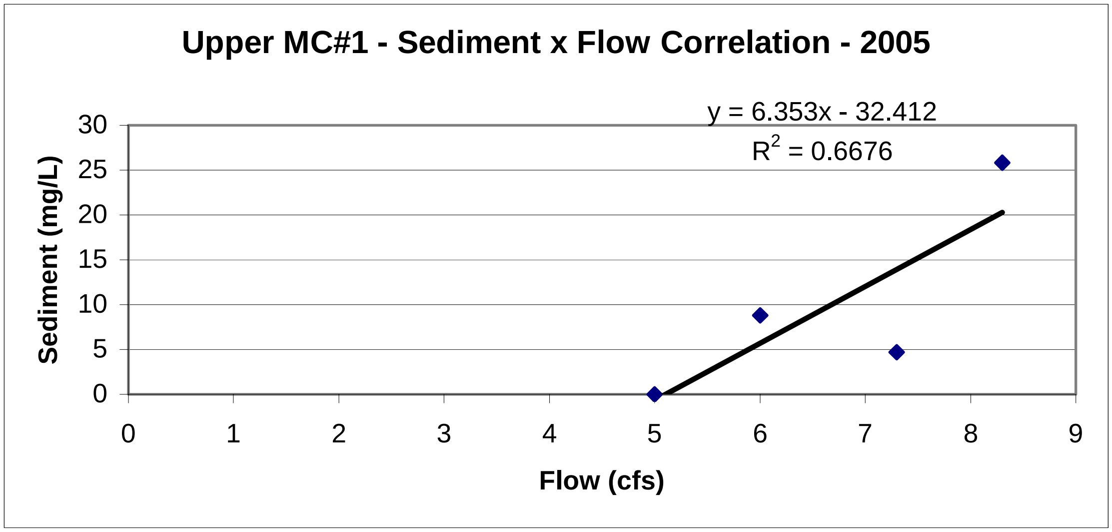
Muddy Creek at Power - Flow x Sediment Correlation
y = 36.264Ln(x) - 53.064
R^2 = 0.6475
Sediment (mg/L)
0
20
40
60
80
100
0
10
20
30
40
50
Flow (cfs)

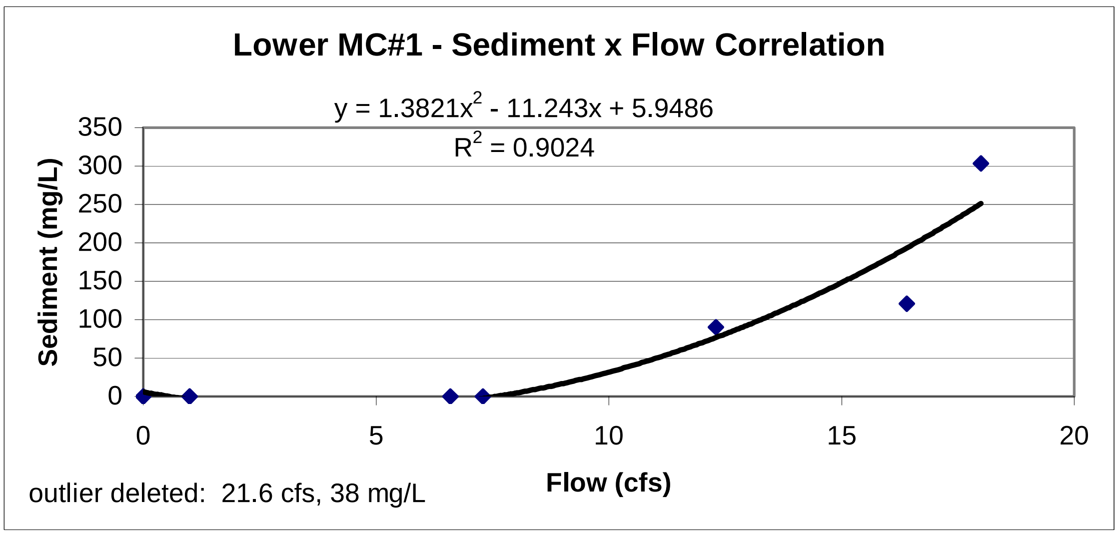


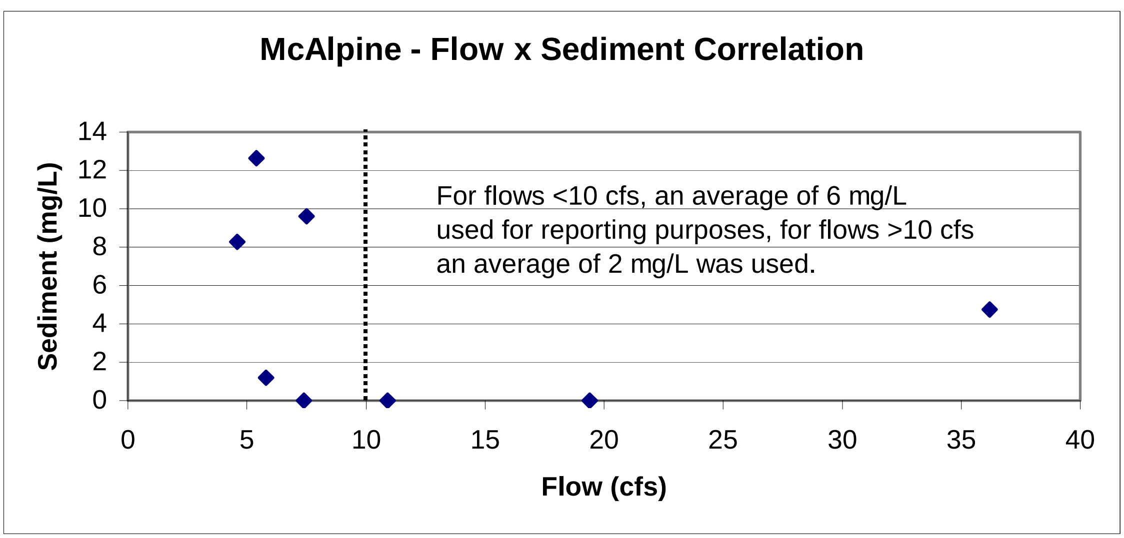
Upper Kloppel Coulee - Flow x Sediment Correlation
y = 0.1213x^2 - 0.1287x + 0.0505
R^2 = 0.9695
Sediment (mg/l)
0
2
4
6
8
10
12
14
0
2
4
6
8
10
12
Flow (cfs)
Outliers deleted: 0.1 cfs, 7 mg/L; 6.7 cfs, 79 mg/L

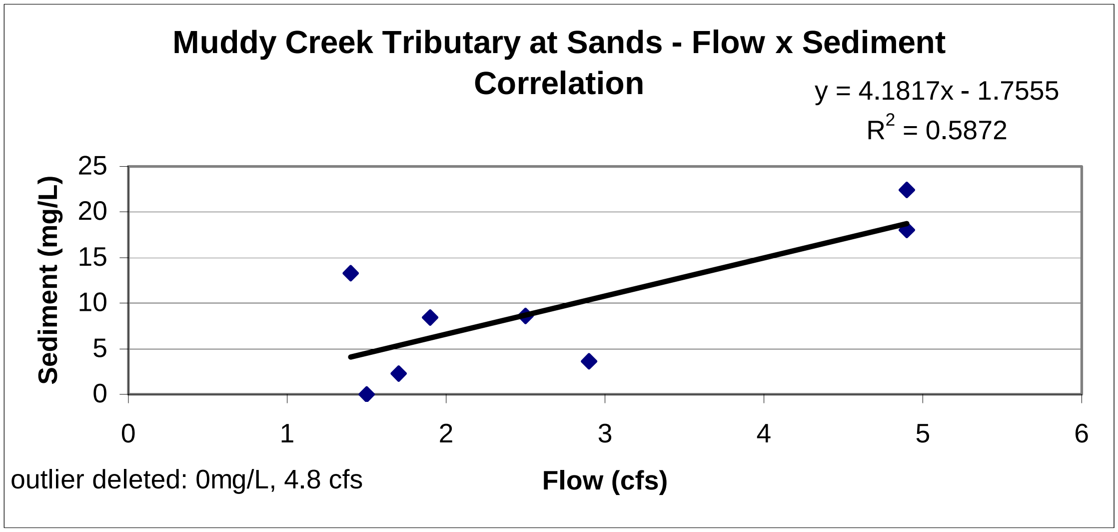


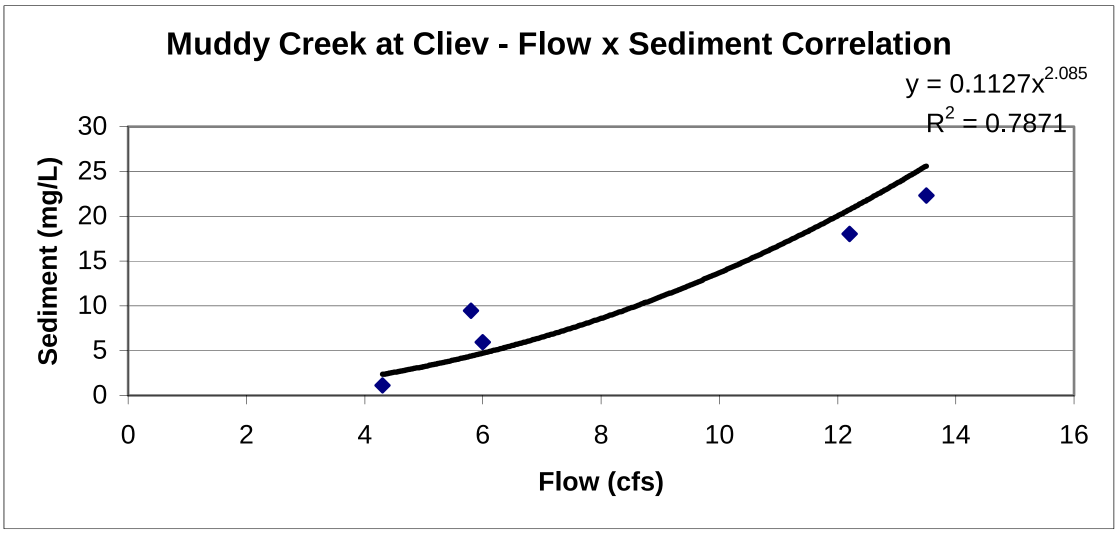
Cordova at Side Coulee - Flow x Sediment Correlation
y = 0.1562x^2 + 2.6264x - 4.1051
R^2 = 0.9662
Sediment (mg/L)
0
50
100
150
200
250
0
5
10
15
20
25
30
35
Flow (cfs)

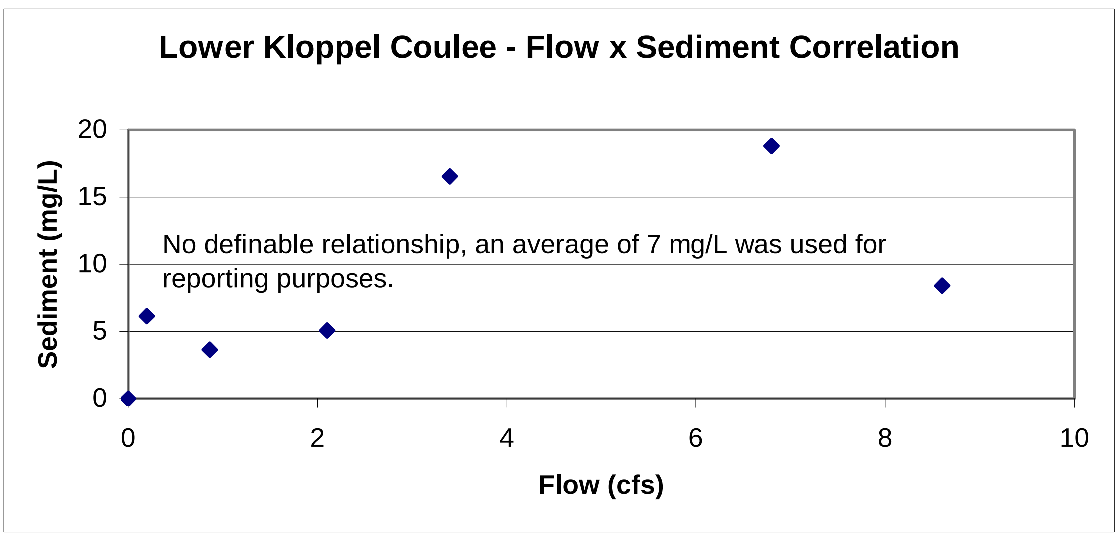

Upper MC#1 - Sediment x Flow Correlation - 2005
y = 6.353x - 32.412
R2 = 0.6676
Sediment (mg/L)
Flow (cfs)
0
5
10
15
20
25
30
0
1
2
3
4
5
6
7
8
9


Lower MC#1 - Sediment x Flow Correlation
y = 1.3821x2 - 11.243x + 5.9486
R2 = 0.9024
Sediment (mg/L)
Flow (cfs)
outlier deleted: 21.6 cfs, 38 mg/L
0
50
100
150
200
250
300
350
0
5
10
15
20


McAlpine - Flow x Sediment Correlation
For flows <10 cfs, an average of 6 mg/L
used for reporting purposes, for flows >10 cfs
an average of 2 mg/L was used.
Sediment (mg/L)
Flow (cfs)
0
2
4
6
8
10
12
14
0
5
10
15
20
25
30
35
40


Muddy Creek Tributary at Sands - Flow x Sediment Correlation
y = 4.1817x - 1.7555
R2 = 0.5872
Sediment (mg/L)
25
20
15
10
5
0
0
1
2
3
4
5
6
outlier deleted: 0mg/L, 4.8 cfs
Flow (cfs)


Muddy Creek at Cliev - Flow x Sediment Correlation
y = 0.1127x2.085
R2 = 0.7871
Sediment (mg/L)
30
25
20
15
10
5
0
0
2
4
6
8
10
12
14
16
Flow (cfs)


Lower Kloppel Coulee - Flow x Sediment Correlation
Sediment (mg/L)
20
15
10
5
0
No definable relationship, an average of 7 mg/L was used for reporting purposes.
0
2
4
6
8
10
Flow (cfs)